SOUTHERN CALIFORNIA AIR QUALITY STUDY
QUALITY ASSURANCE PROGRAM

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ABSTRACT

The methods and results of the Quality Assurance Program for the Southern California Air Quality Study (SCAQS) are described. The program included system audits by ENSR Consulting and Engineering, performance audits by the California Air Resources Board (ARB) and the South Coast Air Quality Management District (SCAQMD), and several laboratory intercomparison studies coordinated by ARB.

System audits included review of standard operational and quality control procedures submitted by all study participants, onsite system audits of AeroVironment (AV) for the SCAQS sampler, Environmental Monitoring Services, Inc. (EMSI) for ions and mass, Environmental Protection Agency (EPA) for elemental composition and speciated hydrocarbons, SCAQMD for routine continuous gases, Tracer Technologies for tracers studies, Sonoma Technology, Inc. (STI) and University of Washington (UW) for airborne air quality and meteorological measurements, and T&B Systems for upper air soundings.

Continuous CO, SO_2, O_3, NO_x, and total hydrocarbons (THC) analyzers operated by the ARB at Long Beach, by General Motors at Claremont, by SCAQMD at Los Angeles - North Main, and by STI and UW aboard the aircrafts were audited during the summer field study. ENSR Consulting and Engineering conducted system audits for all measurements to review operational and quality control procedures and provided overall management of the quality assurance program. Performance audits of continuous gas analyzers and ion analysis were conducted by ARB, and audits of the SCAQS sampler flow rates were conducted by the SCAQMD. Additionally, intercomparison studies were coordinated by the ARB for elemental analysis, speciated hydrocarbons, light absorption and peroxyacetyl nitrate.

ACKNOWLEDGMENTS

We wish to thank the many participants who cooperated to improve and quantify the quality of measurements made during SCAQS. Particular thanks go to Bob Effa of the ARB Quality Assurance Section, whose teams conducted performance audits for continuous gas analyzers and meteorological instruments, and to Bill Bope and Sandy Ryan of the South Coast Air Quality Management District, whose teams conducted performance audits for sampler flow rate and for nephelometers. Dr. Richard Countess of C-E Environmental, Inc., Barbara Wright of ENSR, and Dr. Stanislaw Piorek of Columbia Scientific Industries provided assistance with the performance audits for ion chemistry. We especially thank the following individuals for their participation in the various comparison studies: Dr. Bob Kellogg of NSI Technology Services, Inc.; Dr. John Cooper of NEA, Inc.; Dr. Bill Davis of the California Air Resources Board; Dr. Tom Cahill of the University of California, Davis; Drs. Ken Knapp, Len Stockburger and Bill Lonneman of the EPA; Dr. Rei Rasmussen of the Oregon Graduate Center; Dr. Hal Westberg of the University of Washington; Dr. Ray Weiss of Radiance Research; and Dr. Daniel Grosjean and Ed Williams of DGA, Inc. Finally, we wish to acknowledge the suggestions and assistance of Dr. Susanne Hering of Sonoma Technology, Inc. This project was funded by the Air Resource Board.

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1. SUMMARY

This report reviews the results of the quality assurance (QA) program implemented for the multi-year Southern California Air Quality Study (SCAQS). The overall goal of SCAQS is to develop and archive a comprehensive air quality and meteorological data base for the South Coast Air Basin (SoCAB). The data base will be used to understand the formation of high pollutant concentrations and to evaluate, test, and improve air quality models used to simulate air quality within the study region. The QA program for SCAQS was managed by ENSR Consulting and Engineering (ENSR) and implemented with the assistance of the California Air Resources Board (ARB), the South Coast Air Quality Management District (SCAQMD), and Sonoma Technology, Inc. (STI). Table 1-1 provides a summary of the measurements which comprised the core of the measurement program and were the primary focus of the QA study.

1.1 SCAQS Quality Assurance Program

Quality assurance includes two types of activities: quality assurance (QA) and quality control (QC) audits. The QC activities consist of documented standard operating procedures for sample collection and analysis, data processing, and auditing. These procedures define schedules for periodic calibrations and performance tests. They specify predefined tolerances which are not to be exceeded by performance tests and the actions to be taken when they are exceeded. The QC activities are ongoing activities performed by measurement and data processing personnel. The QC procedures employed during SCAQS were developed, documented and implemented by each measurement group, and reviewed for completeness by the QA auditor.

QA auditing is an external function performed by personnel who are not involved in normal operations. The purposes of the QA audits are to determine whether the QC procedures are adequate and are

TABLE 1-1

SUMMARY OF SCAQS MEASUREMENTS

B & B+ Site Measurements	No. of sites Sum.	Fall
METEOROLOGY		
Wind speed	9	6
Wind direction	9	6
Temperature or dew point	9	6
UV radiation	4	2
GASES (continuous)		
O_3	9	6
NO/NO_x	9	6
SO_2	6	6
CO	9	6
PAN	9	5
GASES (integrated samples)		
SO_2 } in the	9	6
NH_3 } SCAQS	9	6
HNO_3 } Sampler	9	6
Carbonyls	9	6
C1-C10 HC	9	6
H_2O_2	4	0
Toxics	4	2
AEROSOL PHYSICAL PROPERTIES		
Size dist. (0.1–3µm)	3	2
Light scattering	9	6
Light absorption (in SCAQS sampler)	9	6
AEROSOL CHEMISTRY PM-10/PM-2.5: (in SCAQS Sampler)		
Mass	9	6
$SO_4^=$	9	6
NO_3^-	9	6
Cl^-	9	6
NH_4^+	9	6
Elements	9	6
Elemental C	9	6
Organic C	9	6
Size Selective HiVol	9	6
Mass, $SO_4^=$, NO_3^-	9	6
SIZE RESOLVED AEROSOL CHEMISTRY		
$SO_4^=$	3	2
NO_3^-	3	2
Cl^-	3	2
H^+	3	2
NH_4^+	3	2
Na^+	3	2
Elemental carbon	3	2
Organic Carbon	3	2
Elements	3	2

A Site Add'l Measurements	No. of sites Sum.	Fall
GASES (continuous)		
HNO_2, HCHO, NO_2 (DOAS)	2	1
H_2O_2, HCHO, HNO_3 (TDLAS)	1	1
PAN, NO_2 (GC/luminol)	1	1
NO_3 Radical (DOAS)	1	0
GASES (integrated samples)		
C2-C12 HC	3	0
Organic Acids	2	1
Carbonyls (add'l meas. methods)	3	1
Methyl & ethyl alcohol	2	1
NH_3, HNO_2, HNO_3	1	1
Halocarbons	1	0
AEROSOL PHYSICAL PROPERTIES		
Light absorption (add'l methods)	1	1
Path transmittance & radiance	1	0
Long path light extinction	1	1
Size vs. RH	1	0
Light scattering vs. RH	2	0
Detailed fine part. size distribution	2	2
AEROSOL CHEMISTRY (time resolved)		
Semi-cont. aerosol carbon	1	1
Continuous sulfate	2	0
Black carbon	1	1
PM-10 Mass	1	1
AEROSOL CHEMISTRY (integrated samples)		
Carbon 14 (PM-3.5)	3	2
PAHs, Mutagenicity	2	1
Aerosol Acidity	1	1
Elements (PIXE, FAST)	3	2
Br, Pb	1	1
EC, OC; $SO_4^=$, NO_3^-	2	1
Large particle mass, $SO_4^=$, NO_3^-	1	0
SIZE RESOLVED AEROSOL CHEMISTRY (add'l)		
Mass	1	0
Functional Groups	1	0
S, $SO_4^=$, NO_3^-	1	0
Pb	1	0
ACIDITY SAMPLERS (SO_2, HNO_3, HNO_2, NO_2, $SO_4^=$, NO_3^-)		
Calif. Dry Deposition Sampler	1	0
Operat. Evaluation Network Sampler	1	0
EPA Annular Denuder	1	0
EPA Transition Flow Reactor	3	2
Dry deposition Plates	1	0

Other Measurements	No. of sites/flights/releases Sum.	Fall
METEOROLOGY		
Rawinsondes	6	5
Airsondes	2	1
Wind speed/direction	4	3
Temperature	4	3
Acoustic Sounders	2	1
AIRCRAFT FLIGHTS		
LIDAR	9	3
STI	25	12
UW	9	0
PHOTOGRAPHY		
Time lapse	3	2
Still photographs	3	2
TRACER RELEASES		
SF_6	2	2
Perfluorocarbons	8	7

being followed and whether the tolerances for accuracy and precision are being achieved in practice. The QA auditing function consists of two components: system audits and performance audits. System audits include a review of the operational and QC procedures to assess whether they are adequate to assure valid data which meet the desired levels of accuracy and precision. Performance audits establish whether the predetermined specifications for accuracy are being achieved in practice by challenging the measurement system with a known standard sample which is traceable to a primary standard.

1.2 Preliminary Audits

Preliminary audits ENSR conducted before the field study included a review of standard operating procedures and system audits administered via interviews and questionnaires. These system audits reviewed documentation procedures, data management, laboratory procedures, and QC of analyses and measurements. Facilities reviewed included:

- EPA's Atmospheric Research and Exposure Assessment Laboratory (AREAL) for hydrocarbon speciation by gas chromatography (GC) and gas chromatography/mass spectrometry (GC/MS)
- C-E Environmental (C-E) for ion analysis and mass measurements
- EPA and NSI Technology Services Corporation (NSI) for elemental analysis
- SCAQMD for criteria pollutants
- Tracer Technologies for perfluorocarbon tracers
- AV for the SCAQS Sampler
- EMSI for filter ion chemistry.

In addition to the preliminary system audits, a preliminary performance audit using spiked filter samples was conducted for filter ion chemistry at C-E.

1.3 Field Audits

Early during the summer study ENSR managed system audits at Azusa, Burbank, Claremont, Hawthorne, Long Beach, and San Nicolas Island, with support from the ARB QA Section and the SCAQMD Technical Services Division to perform the field measurements. The audit focused on the operation of the SCAQS aerosol/gas samplers, hydrocarbon canister samplers, carbonyl samplers, PAN samplers, and nephelometers. The purposes of these audits were to evaluate the training of operator personnel, to verify that standard operating procedures (SOPs) and QC procedures were being followed properly, to assess the completeness of onsite documentation, and to investigate the condition and setup of instrumentation. Audits were also conducted at Ontario Airport for upper air soundings, and aboard UW and STI aircraft for air quality and meteorological measurements.

The SCAQMD Technical Services Division and ARB QA section conducted flow rate performance audits of onsite measurement instrumentation at Long Beach, Claremont, Los Angeles (North Main), and aboard UW and STI aircraft.

1.4 Special Studies and Intercomparisons

Prior to the field study, AV operated all 10 SCAQS samplers side-by-side to verify equivalency and to determine precision of results. Because of the difficulty of defining performance audit procedures for certain measurements, ARB coordinated comparison studies for elemental analysis, speciated hydrocarbons, light absorption and peroxyacetyl nitrate (PAN).

1.5 Results of the Quality Assurance Program

The following paragraphs summarize the more significant results of the SCAQS QA program. More comprehensive details are provided in the main body of this report.

Preliminary Audits

- Operational and QC procedures for NSI's x-ray fluorescence (XRF) analysis and SCAQMD's measurement of criteria pollutants and meteorological parameters were organized, documented, and long established. No significant recommendations were made.

- Suggestions were presented to EPA for expanding technical documentation, revising data forms, formulating plans for selection of GC/MS samples, and devising replicate analyses to determine precision and the effect of sample storage.

- Operations and laboratory practices at C-E were well organized, but the ammonia/ammonium determinations on oxalic-acid impregnated filters could be improved. Recommendations were made for a new filter for ammonium particle collection and modifications of the operator checklist.

- Tracer Technologies' perfluorocarbon tracer study was found to be well designed, with properly documented QA procedures and data.

Field Audits

- The audit of AV showed that operating procedures were well documented and adequately designed to minimize potential operator error. Flow audit procedures were developed. Problems discovered with nephelometer measurements, station logs at some sites, and the hydrocarbon (HC) canister sampler at three sites were rectified quickly.

- Results of the flow rate audits were good.

- Results for the performance audits of nephelometers were good except at Rubidoux, where instrument response was noisy.

- The gas analyzer audits revealed a number of problems (see Table 1-2) which were traced to calibration system errors. These problems were subsequently corrected.

- Sample manifolds needed cleaning at some SCAQMD sites.

- T&B upper air instrumentation was not yet operational during the audit.

TABLE 1-2

SCAQS GAS ANALYZER AUDITS

Operator	Site	Date	Auditor	Average Deviation From True (%) O_3	CO	NO_2	CO_2	THC
SCAQMD	Los Angeles	06/16/87	1	- 3.7	4.5	- 6.2	0.2	-4.7
		11/19/87	1	- 9.9	4.9	1.4	3.4	6.0
ARB	Long Beach	06/17/87	1	- 4.6	- 5.9	- 6.5	28.8	
		11/17/87	1	- 1.0	- 2.2	10.4	28.0	
GMRL	Claremont	06/18/87	1	- 4.5		- 34.0	- 20.8	
		06/27/87	1		-56.1	- 25.2	- 22.2	
		07/03/87	2			- 40.6		
		09/04/87	3		- 9.9	- 4.5		
	Long Beach	11/17/87	1		- 1.7	- 1.0		
STI	Aircraft	06/22/87	1	- 3.5		- 12.1	2.8	
		11/18/87	1	12.7		10.0		
UW	Aircraft	06/22/87	1	39.9	- 2.8	96.1	46.5	
		06/26/87	1	88.5		84.4	50.9	
		07/27/87	4	119.2		109.1	172.1	

Auditor Key

1 = ARB Quality Assurance Section
2 - ARB Air Surveillance Branch
3 = SCAQMD
4 = Sonoma Technology, Inc.

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Comparison Studies

- A discrepancy in values for soil-related elements was attributed to SCAQS sampler filter sample nonuniformity and the different areas of filter exposure by NEA and EPA/NSI.
- Results of the laboratory comparison for speciated hydrocarbon analysis were within acceptable ranges.
- Following an initial problem due to filter variability and lack of an optical tare, final audit results for optical extinction by absorption were reasonable.

1.6 Recommendations

The SCAQS QA led to general suggestions regarding the application of QA in complex research projects as well as specific recommendations regarding SCAQS measurement areas.

- Because accurate analysis of filter samples often depends on uniform filter deposits, it is important to include checks that characterize the uniformity of the sample deposit. Filter deposit profiles should be included as a standard part of filter sampler specifications.
- A forum should be established with the objective of obtaining a consensus on uniform guidelines for the reporting of speciated hydrocarbon data.
- Finally, short-term, complex field studies should include a shakedown period sufficient to conduct field system and performance audits before the studies are well underway.

The early stages of data validation for SCAQS are now in progress. Formal validation tests are being compiled for each measurement and will be applied during the second and third quarters of 1989. The mechanism is now in place within the Archive to document the identification and resolution of future data problems as well as any resulting modifications. Thus, QA will continue to be an integral part of the SCAQS program for years to come.

2. RECOMMENDATIONS

Experience obtained during the SCAQS QA Program has led to some general observations on the successful application of QA in complex research projects, as well as some suggestions relevant to specific measurement areas.

Filter Deposit Uniformity

Methods for analysis of filter sample deposits that determine concentrations from only a fraction of the filter, or that do not weight all fractions of the filter equally, obviously depend on uniform filter deposits. Measurements for which this may be true include XRF, carbon, and particle light absorption coefficient (b_{abs}). Practical samplers cannot always meet the ideal of uniform filter deposits. Thus, when characterizing a new sampler, it is important to include checks that characterize the uniformity of the sample deposit. We recommend that filter deposit profiles should be included as a standard part of filter sampler specifications.

Speciated Hydrocarbon Data Reporting

The great variety of hydrocarbon species present in polluted air, the number of assumptions required, and the individual nature of various researchers' analytical and reporting approaches, causes moderate difficulty when attempting to compare or evaluate results. Yet precisely because of this variety, QA evaluations and intercomparisons are important. We recommend that a forum be established with the objective of obtaining a consensus on uniform guidelines for the reporting of speciated hydrocarbon data. Items for consideration include:

- unambiguous and uniform naming of compounds, perhaps by including Chemical Abstract Service (CAS) registry number;

- criteria to be satisfied before a chromatographic peak is considered identified rather than unknown;
- reconciliation of total hydrocarbon measurements with the sums of identified and unidentified peaks;
- identification of standard compound classes to be reported as class totals, with completeness criteria determined from the reconciliation of speciated to total hydrocarbons;
- standardization of the treatment of different response factors to different compounds;
- standardization of conventions for reporting ppm carbon vs micrograms of reference compound per cubic meter.

This list is intended only to illustrate the kinds of issues where inconsistencies among investigators make QA more difficult. We are not recommending that uniform analytical procedures be established. We do believe that more uniformity in reporting would be beneficial to the data user.

General Observations

A good QA plan is designed to improve and "assure" data quality, not just to check data quality. As such, it is important that adequate time and effort be allocated to QA before the core sampling program is expected to produce quality data. This is especially important for complex, short-term, one-of-a-kind research studies such as SCAQS. Our experience during the SCAQS confirms our experience with QA for other large studies--QA audits almost inevitably uncover some problems. The problems can generally be resolved, and they need not have a serious impact on data quality if corrected before the study begins in earnest.

Prior to the first SCAQS sample day, considerable effort was spent on shakedown runs, sampler testing, and preliminary QA audits. This effort contributed significantly to the success of the study. However, due to time and funding constraints, many audits and intercomparisons could not be completed until the study was well underway. As a result, problems with continuous gas analyzers and with non-uniformity of SCAQS Sampler filters were not discovered until after the study began. This led to much effort attempting to resolve problems and to correct flawed data.

The situation where problems are detected during a study can probably never be completely avoided. However, we would like to emphasize the benefits obtained through early QA, by making the following recommendation. Short-term field studies should include a shakedown period sufficient to conduct field system and performance audits before the study begins in earnest.

3. INTRODUCTION

In the summer and fall of 1987, a field measurement program was carried out in the SoCAB as part of the SCAQS. SCAQS is a multi-year, integrated air quality study whose overall goal is to develop and properly archive a comprehensive air quality and meteorological data base for the SoCAB. The data will be used to better understand the formation of high pollutant concentrations and to test, evaluate and improve elements of air quality simulation models for oxidants, NO_2, PM_{10}, fine particles, visibility, toxic air contaminants and acidic species. SCAQS is jointly funded by governmental agencies, industry groups and individual corporate sponsors. A wide range of modeling and interpretive data analysis projects are planned by various sponsors. A data archive, consisting of approximately 200,000 individual measurements from 50 groups, is expected in spring 1989.

The production of a data base for the purpose of model evaluation and testing, with the goal of control strategy and regulatory development, requires the collection of data with quantified accuracy and precision. Crucial to the determination of these attributes of a measurement is a well-defined QA program. QA encompasses those activities which complement the measurement process by providing estimates of accuracy, precision, and validity, and by ensuring that these attributes are within acceptable limits.

SCAQS Field Study

The measurement program comprised six intensive study days between June 15 and July 24, five intensive study days between August 20 and September 3, and six intensive study days between November 9 and December 11. During each measurement period, the field study included a network of existing air quality monitoring stations (C-sites); enhanced monitoring stations (nine during the summer period and six during the fall period) located along typical air trajectories to routinely measure aerosol and gases on intensive days (B-sites); one research station each in a source and receptor region in the summer and one station in a source region in the fall (A-sites); a network of stations for meteorological measurements at the surface and aloft on intensive study days; upper air pollutant and light detection and ranging (LIDAR) measurements by aircraft on intensive study days; measurement of selected toxic air contaminants at selected sites; physical and chemical measurements of fog and clouds on intensive study days; special studies on selected study days, including multiple tracer releases; assembly and archiving of supplemental data from existing sources; and a QA program including independent systems and performance audits.

The number of organizations participating in the SCAQS, and the diversity of measurements conducted are tremendous. To prevent this situation from becoming overwhelming, the SCAQS measurements have been classified into a number of measurement areas, and a Measurement Specific Manager (MSM) has been assigned to each area. The MSMs are responsible for overseeing the consistency and quality of data within their areas. The SCAQS measurements, broken down by measurement area, are listed in Table 3-1. The measurements made at the B-sites represent the core of the measurement program and were the primary focus of the QA program.

Quality Assurance

The QA auditing program for SCAQS consists of two components: system audits and performance audits. System audits include a review of the operational and QC procedures to assess whether they are adequate to assure valid data which meet the specified levels of accuracy and precision. After reviewing the procedures, the auditor examines all phases of the measurement or data processing activity to determine whether the procedures are being followed and the operating personnel are properly trained. The system audit is

TABLE 3-1

SCAQS FIELD MEASUREMENTS BY MEASUREMENT SPECIFIC GROUP

Laboratory	PI	Measurements
Meteorological Measurements		
Chuck Bennett, (916) 323-1506		
GM	Wolff	Acoustic Sounder (book of pictures)
NWS	Croes	Routine Ground Based Met Data
SCAQMD	Croes	Routine Ground Based Met Data
SCE/AV	Ellis/Filek	AV 2000 Doppler Acoustic Sounder
STI-B	Blumenthal	Mechanical Met - Catalina Island
TBS	Lehrman	Rawinsondes
TBS	Lehrman	Airsondes
TBS/STI	Lehrman	Mechanical Met Stations
Navy	Croes	Sea Temp., Air Temp., Upper Air Temp. Turbulence
Penn St.	Croes	Upper Air WS WD Turbulence, Surface Met
FIRE	Croes	San Nicolas Island Summer 87 Soundings for FIRE
NWS	Croes	NWS Upper Air: Edwards, Vandenburg
B-Site: Criteria Gases, Bscat, PM_{10}, Hivol, UV, and Surface Met -		
Bart Croes, (916) 323-1534		
AQMD	Bope	CRITERIA, WS/SD, T/DP, TSP, BSCAT
ARB-HS	Kowalski	O_3, CO, NO, NO_x, SO_2, WS/SD, T/DP, RAC Tape Sampler
ARB-HS	Kowalski	Eppley UV Photometer
ARB-HS	Jung	Dasibi Model 2008 Photometric NO_2 Analyzer
AV	Chan	O_3, CO, NO, NO_x, WS/SD, T/DP, TSP
AV	Chan	MRI #1561 Nephelometer (Heated Inlet)
AQMD	Croes/Bope	MRI #1561 Nephelometer (Heated Inlet)
AV	Chan	Eppley UV Radiometer
AV/AQMD	Eden	Andersen SSI (PM_{10}), Hivol, SO_4, NO_3
GM	Wolff	CO, BSCAT, O_3, NO, NO_2, NO_x, SOLARAD, UVRAD
GM	Wolff	DWPT, RH, TEMP, TEMP5, TEMP10, TDIFF, V_WD, V_WS, WS

TABLE 3-1 (Continued)

Laboratory	PI	Measurements
Gases: Hydrocarbons, Aldehydes, and Toxics		
Eric Fujita, (916) 323-1533		
ARB-HS	Croes	ARB Tedlar Bags for Toxics
Bio	Rasmussen	Biospherics Toxics Canister
Bio	Rasmussen	C_1-C_{12} Biospherics Canisters
EPA	Knapp	C_1-C_{12} Biospherics Canisters
ENSR	Taketomo	DNPH Cartridges: Carbonyls
DGA	Grosjean	Formic Acid, Acetic Acid, by Alkaline Cartridges
EMSI	Lev-On	L Ar Trap, Aldehydes, Ketones
EPA-GKP	Lonneman/Ellenson	HC Canisters
EPA-GKP	Lonneman/Ellenson	Aldehydes (DNPH SEP Packs)
EPA-SSB	Knapp	GC and GC/MS for Canisters
GGC	Kaplan	GGC Carbon Cartridges for Alcohols
UCR	Winer	DOAS for HCHO (also listed with HNO_3-NO_2 measurement)
Unisch	MacKay	Unisearch TDLAS for HCHO (also listed with HNO_3-NO_2)
EPA/STI/UW	Knapp	UW/STI Aircraft: Hydrocarbons
ENSR/STI/UW	Taketomo	UW/STI Aircraft: Carbonyls
Gases: PAN		
Eric Fujita, (916) 323-1533		
DGA	Grosjean	PAN by GC, Electron Capture
DGA	Grosjean	PAN - Integrated Measurement for UW and STI Aircraft
EPA-GKP	Lonneman/Ellenson	PAN (GC-ECD)
UD	Stedman	UD GC - luminal detector for PAN
DGA/STI/UW		UW/STI Aircraft: Pan
Gases: Peroxide		
Eric Fujita, (916) 323-1533		
EMSI	Lev-On	H_2O_2 Impingers
SCE-UCLA	Ellis/Kaplan	Hydrogen Peroxide
Unisch	MacKay	Unisearch TDLAS for H_2O_2 (listed above with HNO_3 meas.)

TABLE 3-1 (Continued)

Laboratory	PI	Measurements
Gases: HNO_3, NO_2, and Other		
Eric Fjuita, (916) 323-1533		
EPA-GKP	Lonneman/Ellenson	Monitor Labs 8840 NO_x with Nylon Prefilter
UCR	Winer	DOAS for NO_2, HNO_2, HCHO, NO_3
UD	Stedman	UD Luminol Detection of HNO_3
Unisch	MacKay	Unisearch TDLAS for Formaldehyde, H_2O_2, HNO_3
AIHL	Appel	Particle Sulfate
AIHL	Appel	Total Strong Acid, pH
AIHL	Appel	HONO, M73, HNO_3, NH_3
AIHL	Appel	O_3, NO/NO_y with Na_2CO_3 Denuder
Aerosols: SCAQS Sampler and Aircraft Filters		
Susanne Hering, (707) 527-9372		
AV	Chan	SCAQS Sampler Field Sampling Data
EMSI	Countess	SCAQS Sampler Ion Chemistry Filter Loadings
ENSR	Taketomo	SCAQS Sampler Carbon Filter Loadings
RR	Weiss	SCAQS Sampler B-abs Filter Loadings
EPA	Knapp	SCAQS Sampler XRF Ambient Concentrations
GM	Wolff	SCAQS Sampler, SSI Hivol
STI	Anderson	Aircraft: Aerosol Filter Chemistry
Others/UW	Hegg	Aircraft: Aerosol Filter Chemistry
Aerosols: Filter Chemistry Sampling		
Susanne Hering, (707) 527-9372		
EPA-SSB	Knapp	Low-vol and Hivol Quartz Filters for Organics
GGC	Kaplan	GGC-C_{14} (Hivol)
OGC	Turpin	Cumulative OC, EC Size Distributions, Nighttime Pb/Br
UCD	Nakamura	IMPROVE Cyclone Filter Samples/PIXE
UCLA-2	Main	Dichots for Carbon, Mass, XRF, NO_3, SO_4
UCR	Atkinson	SSI Hivols, Hivols, Tenax Columns, and PUF for PAHs

TABLE 3-1 (Continued)

Laboratory	PI	Measurements
Aerosols: Size Resolved Chemistry		
Susanne Hering, (707) 527-9372		
AIHL	John	Berner Impactor for Inorganic Ion Size Distributions
UCLA-1	Allen	Low Pressure Impactor/FTIR
UCD	Nakamura	UCD Drum Impactor for PIXE (Elemental Distributions)
UCLA-1	Allen	LPIs for FTIR Functional Groups, S and NO_3
UCLA-2	Main	LPI for Pb Distributions
UM	McMurry	MOUDI for OC, EC
UM	McMurry	MOUDI for Mass
UM	McMurry	Rh-controlled Tandem DMAs, Reaction and Growth DMAs
Aerosols: In Situ Chemistry Measurements		
Susanne Hering, (707) 527-9372		
ARB-Sacr.	Croes	MDA BAM Sampler (Beta Gauge)
OGC	Huntzicker	Continuous Sulfate
OGC	Huntzicker	In Situ Carbon
Aerosols: Physical Size Distributions		
Susanne Hering, (707) 527-9372		
AV	Moon	Climet 208 OPC, PMS LASX Probe, TSI 3030 EAA
UM	McMurry/Hering	DMA/OPC Calibrations
UV	Reischl	Classifier for Fine dN/dDp
Visibility Parameters		
Susanne Hering, (707) 527-9372		
Ford	Adams	Spectrophone
Ford	Adams	Nephelometer, Filter for Black Carbon
LBL	Hansen	Aetholometer
STI-R	Richards	Path Transmittance and Radiance
UI	Rood	UI RH-Temp. Controlled Nephelometer Measurements
UV	Hitzenberger	Nuclepore Filter for Babs
UV	Hitzenberger	Telephotometer-10 Wavelengths, Babs by Nuclepore Filter

TABLE 3-1 (Continued)

Laboratory	PI	Measurements
Acidic Particle and Vapor Samplers		
Lowell Ashbaugh, (916) 323-1507		
ARB-HS	Horrocks	Denuder Difference for HNO_3, NO_3^-
EPA-GKP	Ellenson	Annular Denuder (on roof)
EPA-SSB	Knapp	Transition Flow Reactors for Inorganics
ENSR	Heisler	OEN Acid Sampler
Dry Deposition Measurements		
Lowell Ashbaugh, (916) 323-1507		
CMU	Davidson	Dry Deposition Foils
DMU	Davidson	Dry Deposition Onto Plants
IIT	Noll	Rotary Impactor for Coarse Particles
IIT	Noll	Deposition Plates
STI and UW Aircraft - Gases, Nephelometer, Met, Position		
Bart Croes, (916) 323-1534		
ARB-Sacr.	Bennett	Dasibi 1003: O_3 Aloft - Aircraft
STI	Anderson	Aircraft: O_3, CO, NO, NO_x, SO_2, T/DP, Position, Altitude
STI	Anderson	Aircraft: MRI #1569 Neph., PMS ASASP-X Aer Size Dist
UW	Hegg	Aircraft: O_3, NO, NO_x, SO_2, T/DP, BSCAT, Position, Alt.
Special Studies		
Bart Croes, (916) 323-1534		
GM	Nelson	GM Smog Chambers
SCE-GGC	Kaplan	City of Hope Aerosol Samp. and Organic Reactivity Studies
SCE-GGC	Kaplan	Dichotomous Samplers, $PM_{3.5}$ Hivol
SCE-GGC	Kaplan	Denuder Quartz Filters
SCE/AV	Gains	Edison Van: O_3, CO, NO, NO_x, SO_2, WS/SD, T/DP
SCE/AV	Gains	Edison Van Beckman Dichot.

TABLE 3-1 (Continued)

Laboratory	PI	Measurements
Fog and Liquid Phase Studies		
Eric Fujita, (915) 323-1533		
CIT-Fog	Hoffman	Cloud/Fog Water Chemistry
SCE-GGC	Kaplan	Fog Samples
Tracers and Lidar Aircraft		
Chuck Bennett, (916) 323-1506		
EPA-LV	McElroy	Aircraft Lidar Measurements
CIT	Shair	SF6 Tracer Releases and Sampling
DRI	D. Miller	Urban Tracers
SCE-TT	Ellis/England	Perfluorocarbon Tracers
Photography		
Doug Lawson, (916) 324-8496		
RP	Richmond	Time Lapse 16mm Motion Pictures (3 sites)
RP	Richmond	Still 35mm Photos (2 views at each of 3 sites)
Emissions and Source Profiles		
Gary Agid, (916) 322-6021		
Radian	Oliver	Day-specific Emissions Inventories
SW	Ingalls	Tunnel Sampling - Emissions Inventory
UCLA-2	Friedlander	Tunnel Sampling - Automotive Pb Distributions

a cooperative assessment resulting in improved data. System audits were conducted for:

- hydrocarbon speciation,
- SCAQS filter sampler,
- SCAQS filter ion chemistry,
- SCAQS filter XRF analysis,
- criteria gas measurement,
- tracer studies, and
- field system audits.

Performance audits establish whether the predetermined specifications for accuracy are being achieved in practice. For measurements, the performance audit involves challenging the measurement/analysis system with a known standard sample that is traceable to a primary standard. Performance audits of data processing involve independently processing samples of raw data and comparing the results with reports generated by routine data processing. Performance audits were conducted for:

- Flow rates for the SCAQS Samplers, carbonyl samplers, aerosol particle counters, impactors, and size-selective inlet (SSI) Hivols;
- continuous analyzers for O_3, SO_2, NO_2, CO, THC, and CH_4;
- nephelometers; and
- meteorological measurements.

The specialized nature of many measurements conducted during the SCAQS precluded simple performance audits for these measurements. Core measurements that fall into this category include XRF, hydrocarbon speciation, b_{abs}, PAN, and upper air meteorological soundings. Intercomparison studies were used to assess the representativeness, accuracy, and precision of these measurements. In addition to these studies, a special study was conducted to assess the performance of the newly designed SCAQS Sampler before the study began.

Report Organization

The QA activities performed for the SCAQS have been broadly grouped into the following categories:

- preliminary audits,
- field audits, and
- special studies and intercomparisons, and
- discussion of measurement accuracy and precision.

Each of the subsequent chapters of this report, covers a specific category of activity. Within these chapters, the descriptions of QA methods, results, follow-up, and conclusions, are grouped together for specific QA activities. The results and conclusions, and the recommendations resulting from each activity, are presented in the Summary and Conclusions, and the Recommendations chapters.

4. PRELIMINARY AUDITS

After review of SOPs, preliminary system audits were conducted for:

- hydrocarbon speciation by GC/GC-MS (EPA AREAL),
- elemental analysis by XRF (EPA/NSI),
- criteria pollutants (SCAQMD),
- perfluorocarbon tracers (Tracer Technologies),
- the SCAQS Sampler (AV) and
- filter ion chemistry (EMSI).

The system audits were conducted through review of SOPs, interviews, and completion of detailed questionnaires. These audits were conducted at the measurement laboratories for EPA, EPA/NSI, AV, and EMSI, and through telephone interviews for the SCAQMD and for Tracer Technologies.

The system audits addressed issues including documentation, training, analytical methodologies, instrumentation, sources and preparation of reagents, standards, work space, sample handling, data processing, QC, and use of QC data. The objective of the system audits was to review planned measurement methods to ensure that they produced data that met the quality objectives of the SCAQS program. The review had four main components:

- technical adequacy of the method to meet desired objectives for sample integrity, and for data precision, accuracy, and detection limits;
- a QC plan to demonstrate sample integrity and data precision;
- adequate documentation for technical assessment by eventual users of the data;
- adequate documentation for personnel conducting the measurements.

Another objective of the system audits was to provide recommendations for a performance audit or test to assess measurement accuracy. The "results" of the preliminary system audits consisted of suggestions and recommendations to enhance the measurement plan.

In addition to the preliminary system audits, a preliminary performance audit was conducted for filter ion chemistry analyses at EMSI. The performance audit consisted of challenging the EMSI laboratory with spiked filter samples.

4.1 Hydrocarbon Speciation

On May 8, 1987, John Collins and Kochy Fung of ENSR visited Ken Knapp and Len Stockburger at the EPA AREAL in Research Triangle Park, North Carolina. At this time procedures for hydrocarbon speciation were still in development. Our recommendations were to:

- document procedures to a level of detail adequate for subsequent technical review,
- prepare sample handling and data forms,
- develop an explicit plan for the selection of GC-MS samples,
- design explicit procedures that would be used to determine the precision of field data.

Technical documentation, data forms, a plan for selection of GC-MS samples, and a plan for replicate analyses to determine precision and sample storage effects were eventually formalized.

The audit revealed that the accuracy of hydrocarbon data from any GC system designed to quantify a large number of species is affected by choice of standards, assumptions about response factors, and by difficulties in peak identification. Because these issues cannot be addressed by a simple performance audit, an intercomparison study was recommended. The results of the intercomparison study are given in Chapter 7.

4.2 XRF Analysis

On May 8, 1987, John Collins visited Ken Knapp and Bob Kellogg at the EPA/NSI Laboratories in Research Triangle Park, North Carolina. Procedures for XRF analyses at this laboratory were well established. Sample handling, analytical procedures, data processing, and QC appeared to be of high quality and were well organized and well documented. No significant recommendations were made as a result of this audit.

The audit revealed that measurement accuracy cannot be easily assessed by a simple performance audit due to assumptions regarding particle size distributions and other matrix effects. An intercomparison involving SCAQS samples, NIST (formerly NBS) standards, and Micro-Matter standards was recommended. The results of the intercomparison are given in Chapter 7.

4.3 Criteria Pollutants and Meteorology

On June 19, 1987 John Collins conducted a telephone interview with Bill Bope of the SCAQMD. The District operates the air quality monitoring stations in compliance with EPA QA/QC requirements for National Air Surveillance Network (NASN) stations. Each station is audited annually by an independent group within SCAQMD. In addition, selected stations are audited each year by the QA section of the ARB.

The interview demonstrated that existing procedures and routine operations are sufficient to meet the needs of the SCAQS. The only recommendations were to clean all sample manifolds before the study began, and to ensure that station operators receive special training if they will operate any new equipment special to the SCAQS.

Performance audits would be obtained by arranging a special visit of the ARB QA section auditing team.

4.4 Perfluorocarbon Tracer Study

A preliminary system audit of the perfluorocarbon tracer study was conducted through review of the Quality Assurance Plan prepared by Tracer Technologies, and through telephone interview with Mr. Thomas Rappolt, Tracer Technologies QA Manager for the study on May 14, 1987. Issues addressed by the review included release system calibrations, sampler calibrations, expected detection limits, sample handling and identification, field operator procedures, operator training, and logistics. The review and interview demonstrated that the study was well designed, and incorporated well documented QA procedures and data. Due to the specialized nature of the measurements, no field performance audit procedures were developed.

4.5 SCAQS Sampler and SCAQS Sampler Ion Chemistry

Preliminary audits for SCAQS Sampler filter chemistry involved both system and performance audits. ENSR reviewed methodology, reviewed side-by-side SCAQS Sampler testing results (described more fully in Chapter 6, Special Studies and Intercomparisons), visited the chemistry laboratory, visited field operations headquarters, helped design performance audits for laboratory and field operations, and helped interpret performance audit results. The QA efforts combined effectively with the final stages of method development and testing, to significantly improve the sampling and analysis method.

On May 29, 1987, Chris Lanane of ENSR visited Alex Barnett of AV to review SCAQS Sampler operation and documentation, and to develop a flow rate performance audit procedure. The audit showed that operating procedures were well documented, and that the procedures, as well as the sampler itself, were adequately designed to minimize potential for operator error. The operators were receiving training on the sampler in the course of final sampler testing. Flow audit procedures were developed.

On June 11, 1987, John Collins and Barbara Wright of ENSR visited Richard Countess of C-E at C-E's facilities in Camarillo, California. The auditors reviewed procedures for filter sample and denuder preparation, filter kit preparation, filter numbering, sample logging, mass determinations, extraction procedures, analytical instrumentation and reagents, calibration procedures, and data recording and data reduction. Overall, the operation appeared well organized and good laboratory practice was followed throughout. Accuracy, precision, and detection limits for the SCAQS Sampler collection and analysis were as yet undemonstrated. Results of the side-by-side precision testing and the performance audits would be used to demonstrate the adequacy of the SCAQS Sampler collection and analysis to meet the needs of the SCAQS.

A review of methodology and results of precision testing indicated that accuracy, precision, and detectability of ammonia/ammonium determinations on oxalic acid impregnated filters could be significantly improved. As a result, a new filter was selected for ammonium particle collection, and prevention of contamination to active filters was given extra attention. Review of precision testing results uncovered a number of anomalous data values that were ultimately attributed to specific operator errors that occurred because the operators were still being trained while conducting the precision tests. The problems could have been detected and corrected in the field with additional checks. ENSR recommended specific operator checks of filter deposit and filter holder tightness when unloading the filter holders in the field, and these were incorporated into the operators' checklist.

Laboratory performance audits were conducted by evaluating C-E's analysis of filters spiked with known amounts of ions. The audit took several iterations as problems were discovered and corrected, and eventually demonstrated good analytical results by C-E. A summary of the results is given in Table 4-1. More detailed results are shown in Appendix A. The following is a chronological description of the C-E performance audit.

C-E prepared filters for field use, including impregnated filters, and transmitted them to Columbia Scientific Inc. (CSI). CSI spiked replicate sets of filters and returned a number of sets to C-E for analysis. When C-E analyzed these filters, it was discovered that: results for nitrate on nylon filters were good, but problems occurred with CSI's spiking procedures for Teflon filters, with C-E's analysis for SO_4 on potassium carbonate impregnated filters, and with C-E's analysis for NH_4 on oxalic acid impregnated filters. A subsequent analysis of the CSI spiked filters by ENSR's laboratory confirmed problems with CSI's Teflon spikes and with C-E's analysis of impregnated filters.

Rather than preparing a new set of Teflon spikes, a set of Teflon filter samples from the precision testing being conducted by AV was split between C-E and ENSR for analysis of SO_4, NO_3, and NH_4. The results, summarized in Table 4-1, are given in Appendix A. The results indicate very good agreement between laboratories for ions on Teflon filters.

After review of analytical procedures for ions on impregnated filters, improvements in calibration procedures were suggested, and a new round of audit spiking was initiated. C-E prepared a number of impregnated filters and forwarded them to ENSR for spiking. ENSR spiked these filters and verified quantitative recovery using the extraction and analysis methods employed by C-E. C-E analyzed a number of these spikes and demonstrated reasonable results for NH_4 on oxalic acid impregnated filters, but results for SO_4 on carbonate impregnated filters were still inadequate.

TABLE 4-1

C-E ENVIRONMENTAL LABORATORY AUDIT

Nitrate Off Nylon Filters

Sample ID	Ref. µg/fil	Ref. Prec. µg/fil	Meas. µg/fil	Corr. µg/fil	Dev. (%)	Aver.	Dev. (%)
June 1987, Ref. Lab-CSI							
201	.00		1.15	.27		.15	
208	.00		.91	.03			
226	3.96	.01	5.18	4.30	8.6	4.39	10.7
244	3.96	.01	5.35	4.47	12.9		
250	15.90	.10	18.13	17.25	8.5	17.10	7.5
271	15.90	.10	17.83	16.95	6.6		
278	79.30	.30	80.60	79.72	.5	79.82	.7
296	79.30	.30	80.80	79.92	.8		
Lab Blank			.88				

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TABLE 4-1 (Continued)

Sulfate Off Carbonate Impregnated Filters

Sample ID	Ref. µg/fil	Ref. Prec. µg/fil	Meas. µg/fil	Corr. µg/fil	Dev. (%)	Aver.	Dev. (%)
July 1987, Ref. Lab-CSI							
405	.00		.69	.08		.03	
410	.00		.59	.02			
437	4.04	.01	4.53	3.92	- 3.0	4.19	3.7
442	4.04	.01	5.07	4.46	10.4		
451	10.11	.03	10.35	9.74	- 3.7	9.61	- 5.0
462	10.11	.03	10.08	9.47	- 6.3		
484	50.55	.17	51.72	51.11	1.1	51.42	1.7
492	50.55	.17	52.33	51.72	2.3		
Lab Blank			.61				
September 1987, Ref. Lab-CSI							
407	.00		1.96	.84		.72	
413	.00		1.73	.60			
435	4.04	.01	4.88	3.76	- 7.0	3.86	- 4.4
445	4.04	.01	5.10	3.97	- 1.8		
461	10.11	.03	10.48	9.35	- 7.5	9.35	- 7.5
466	10.11	.03	10.48	9.35	- 7.5		
485	50.55	.17	48.45	47.33	- 6.4	48.70	- 3.7
493	50.55	.17	51.21	50.08	- .9		
Lab Blank			1.13				

TABLE 4-1 (Continued)

Sulfate Off Carbonate Impregnated Filters (Continued)

Sample ID	Ref. µg/fil	Ref. Prec. µg/fil	Quad Uncor.	Dev. (%)	Ave. µg/fil	Ave. Dev. (%)	Linear Cor.	Dev. (%)	Ave. µg/fil	Ave. Dev. (%)
November 1987, Ref. Lab-ENSR										
13	.00		53.44				51.17			
14	.00		1.81				1.34			
15	.00		- 1.17							
16	2.21	.04	.65	- 70.6			2.08	- 5.9		
17	2.21	.04	17.72	701.8			19.98	804.1		
18	2.21	.04	.62	- 71.9			1.52	- 31.2		
19	6.37	.25	5.91	- 7.2	5.65	- 11.3	6.44	1.1	6.03	- 5.4
20	6.37	.25	5.72	- 10.2			5.96	- 6.4		
21	6.37	.25	5.33	- 16.3			5.68	- 10.8		
22	16.48	.90	16.19	- 1.8	14.87	- 9.8	16.40	- .5	15.80	- 4.1
23	16.48	.90	13.71	- 16.8			15.80	- 4.1		
24	16.48	.90	14.71	- 10.7			15.20	- 7.8		
Lab Blank							1.00			

Note: Original calibration is a quadratic fit for point from .1 to 25 µg/ml. Audit samples spanned .2 to .5 µg/ml. Revised data used three calibration points between 0 and 1 µg/ml plus zero and linear fit.

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TABLE 4-1 (Continued)

Ammonium Off Oxalic Impregnated Filters

Sample ID	Ref. Ref. µg/fil	Prec. µg/fil	Meas. µg/fil	Corr. µg/fil	Dev. (%)	Aver.	Dev. (%)
July 1987, Ref. Lab-CSI							
305				.21		.23	
306				.25			
339	1.99	.01		2.07	4.0	1.42	- 28.6
340	1.99	.01		.77	- 61.3		
361	5.98	.02		4.61	- 22.9	3.34	- 44.2
362	5.98	.02		2.06	- 65.6		
391	19.95	.07		9.66	- 51.6	10.22	- 48.8
392	19.95	.07		10.78	- 46.0		
Lab Blank 1				.16			
Lab Blank 2				.42			
September 1987, Ref. Lab-CSI							
304				.39		.26	
303				.12			
341	1.99	.01		2.14	7.5	2.17	9.0
342	1.99	.01		2.20	10.6		
355	5.98	.02		5.93	- .8	6.32	5.6
356	5.98	.02		6.70	12.0		
393	19.95	.07		17.41	- 12.7	18.46	- 7.5
394	19.95	.07		19.51	- 2.2		

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TABLE 4-1 (Continued)

Ammonium Off Oxalic Impregnated Filters (Continued)

Sample ID	Ref. µg/fil	Ref. Prec. µg/fil	Quad Uncor.	Dev. (%)	Ave. µg/fil	Ave. Dev. (%)	Linear Cor.	Dev. (%)	Ave. µg/fil	Ave. Dev. (%)
November 1987, Ref. Lab-ENSR										
13	.00		.28		.10		.34		.16	
14	.00		.18				.24			
15	.00		- .17				- .10			
16	2.61	.10	3.62	38.7	3.49	33.8	3.61	38.3	3.48	33.3
17	2.61	.10	3.70	41.8			3.68	41.0		
18	2.61	.10	3.16	21.1			3.15	20.7		
19	6.16	.08	6.26	1.6	6.83	10.9	6.20	.6	6.75	9.6
20	6.16	.08	7.31	18.7			7.22	17.2		
21	6.16	.08	6.92	12.3			6.84	11.0		
22	17.13	.15	17.92	4.6	16.78	- 2.0	17.72	3.4	16.59	- 3.2
23	17.13	.15	14.22	- 17.0			14.04	- 18.0		
24	17.13	.15	18.21	6.3			18.00	5.1		
Lab Blank							.90			

Note: *Original calibration is a quadratic fit for point from .1 to 25 µg/ml. Audit samples spanned .2 to .5 µg/ml. Revised data used three calibration points between 0 and 1 µg/ml plus zero and linear fit.*

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Further review of analytical procedures suggested improvements in data reduction procedures. C-E adopted these procedures, and subsequent application of the new data reduction procedures to earlier audit data showed good results for SO_4 on carbonate impregnated filters.

Table 4-2 shows C-E's final results for impregnated filters spiked by ENSR. Due to a communications mixup, the audit concentrations were about a factor of 10 lower than concentrations expected during SCAQS intensives. Thus, the erratic behavior at low levels in the carbonate impregnated filter audit, and the small positive offset in the oxalic impregnated filter audit, were not considered major problems. In view of program time constraints, and the significant improvements in analytical methods already achieved, auditing was concluded.

TABLE 4-2

PERFORMANCE AUDIT OF C-E ANALYSIS OF IONS ON IMPREGNATED FILTERS

Sulfate on Carbonate Impregnated

ENSR SPIKE		C-E		
SO_4 µg/filter	Precision µg/filter (%)	Recovery µg/filter	Mean µg/filter % Recov.	Precision µg/filter (%)
0.00	NA	53.44 1.81 - 1.17	NA	NA
2.21	0.04 2%	0.65 17.72 0.62	NA	NA
6.37	0.25 4%	5.91 5.79 5.33	5.68 89%	0.31 5%
16.48	0.90 5%	16.19 13.71 14.71	14.87 90%	1.25 8%

Note: Due to a communications mixup, audit samples were prepared for concentrations approximately 10 times lower than expected during the SCAQS study. Thus, the unresolved erratic behavior at very low levels was discounted.

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TABLE 4-2 (Continued)

Ammonium on Oxalic Impregnated

ENSR SPIKE		C-E[a]		
SO_4 µg/filter	Precision µg/filter (%)	Recovery µg/filter	Mean µg/filter % Recov.	Precision µg/filter (%)
0.00	NA	1.02 0.92 0.57 0.52[b] 0.96[b]	0.80	0.23
2.61	0.10 4%	3.56 3.64 3.10	3.44 132%	0.29 8%
6.16	0.08 1%	6.20 7.25 6.86	6.77 110%	0.53 8%
17.32	0.15 1%	17.86 14.16 18.15	16.73 97%	2.22 13%

[a] Blank corrected by 0.80 µg/filter.
[b] Laboratory blank.

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5. FIELD AUDITS

Field performance audits were conducted for continuous gas analyzers, meteorology, nephelometers, and sampler flow rates. The performance audits were managed by ENSR and utilized the support of the ARB QA Section and the SCAQMD Technical Services Division (TSD) to perform the field measurements. In addition, ENSR personnel conducted field system audits at the monitoring locations.

5.1 Field System Audits

ENSR conducted system audits early during the summer study at the locations shown in Table 5-1. The auditor interviewed the station operator for general knowledge of air quality monitoring, knowledge of the SCAQS program, and knowledge of the particular instrumentation for which the operator was responsible. The audit focused on the SCAQS Sampler, the hydrocarbon canister sampler, the carbonyl sampler, the PAN sampler, and nephelometers, though additional measurements were evaluated at some sites. After interviewing the operator, the auditor observed the operator perform routine duties such as SCAQS Sampler filter change procedures. Onsite documentation was reviewed for completeness, and the condition and setup of SCAQS instrumentation were evaluated. QC procedures and data for continuous gas analyzers were also evaluated.

The results of the system audits are summarized below.

- Operator knowledge of all procedures and schedules was good at all locations except for nephelometer measurements. AV's training, scheduling and handling procedures were excellent.
- Onsite documentation and data recording forms were good at all sites except that station logs were not available at some sites.

TABLE 5-1

FIELD SYSTEM AUDIT LOCATIONS

Audited	Location	Audit Date
Core Measurements	Azusa	06/19/87
Core Measurements	Burbank	06/20/87
Core Measurements	Claremont	06/19/87
Core Measurements	Hawthorne	06/20/87
Core Measurements	Long Beach	06/17/87
Core Measurements	San Nicolas Island	06/15/87
T&B Systems	Ontario Airport	06/20/87
STI Aircraft	Ontario Airport	06/20/87
UW Aircraft	Ontario Airport	06/20/87
SCAQMD	Telephone Interview	06/19/87

- Instrument setup and location were good at all sites with the exception of the HC canister sampler at three sites. Sample manifolds needed cleaning at some SCAQMD sites.

- T&B upper air instrumentation was not yet operational at time of audit.

AV quickly rectified all the identified problems.

5.2 Flow Rate Performance Audits

The SCAQMD TSD conducted flow rate performance audits for SCAQS samplers and carbonyl samplers. In addition to these core samplers, the SCAQMD TSD also audited flow rates for the DRUM and MOUDI, and the Climet OPC, PMS Probe, and TSI EAA aerosol particle counters. The ARB QA Section audited flow rates for Hivols and SSI PM_{10} Hivols, including SSI PM_{10} Hivols installed and calibrated by SCAQMD TSD at the Long Beach and Claremont A-sites.

SCAQS Sampler

Results for audits of SCAQS Sampler flow rates are shown in Table 5-2 and summarized in Table 5-3. The results are generally very good. Differences between AV and the audit values are almost always within 10 percent, with the following exceptions. Sampler channel 2, showed a difference of ± 12 percent in three out of ten audits. The summer audit at Downtown Los Angeles showed a consistent difference of about 16 percent for sampler channels 7 through 12, but these large differences were not observed during the fall audit of this site. There are not sufficient audit values to allow quantitative calculation of precision for flow measurements. The audit values are only used to assess the reliability of flow precision calculated by AV from routine QC data.

TABLE 5-2

SCAQS SAMPLER FLOW AUDIT RESULTS

SITE	DATE	SAMPLER	SAMPLER ID	TYPE	NOMINAL FLOW	SCAQMD AUDIT FLOW	ROTAMETER READING	SLOPE	INTERC.	AV FLOW	DELTA	DELTA PERCENT
ANAHEIM	07/24/87	SCAQS	CHAN. 1	NYLON	9-13	10.40	11.00	0.967	0.171	10.81	0.41	3.92%
		"	CHAN. 2F	ZFLOUR	20-25	19.70	19.75	0.965	0.645	19.70	0.00	0.02%
		"	CHAN. 2B	CARBONATE	20-25	19.70	19.75	0.965	0.645	19.70	0.00	0.02%
		"	CHAN. 3	NYLON	8-10	8.60	8.65	0.967	0.171	8.54	-0.06	-0.75%
		"	CHAN. 4	NYLON	8-10	8.70	8.75	0.967	0.171	8.63	-0.07	-0.78%
		"	CHAN. 5	OXALIC ACD	3-5	4.20	4.30	0.967	0.171	4.33	0.13	3.07%
		"	CHAN. 6	POLYCARB.	4-6	4.90	4.80	0.967	0.171	4.81	-0.09	-1.78%
		"	CHAN. 7	QUARTZ	32-37	34.50	34.60	0.965	0.645	34.03	-0.47	-1.35%
		"	CHAN. 8	TEF.PREWGD	32-37	33.40	34.00	0.965	0.645	33.46	0.05	0.16%
		"	CHAN. 9F	TEFLON	32-37	33.70	34.00	0.965	0.645	33.46	-0.25	-0.73%
		"	CHAN. 9B	QUARTZ	32-37	33.70	34.00	0.965	0.645	33.46	-0.25	-0.73%
		"	CHAN.10	QUARTZ	32-37	34.50	34.60	0.965	0.645	34.03	-0.47	-1.35%
		"	CHAN.11	TEF.PREWGD	32-37	34.50	34.90	0.965	0.645	34.32	-0.18	-0.51%
		"	CHAN.12	TEFLON	32-37	33.70	34.00	0.965	0.645	33.46	-0.25	-0.73%
		"		DENUDER	3-5							
AZUSA	07/01/87	SCAQS	CHAN. 1	NYLON	9-13	10.30	10.90	0.996	0.145	11.00	0.70	6.81%
		"	CHAN. 2F	ZFLOUR	20-25	20.20	22.00	1.018	0.325	22.72	2.52	12.48%
		"	CHAN. 2B	CARBONATE	20-25	20.20	22.00	1.018	0.325	22.72	2.52	12.48%
		"	CHAN. 3	NYLON	8-10	8.60	9.00	0.996	0.145	9.11	0.51	5.92%
		"	CHAN. 4	NYLON	8-10	8.80	9.40	0.996	0.145	9.51	0.71	8.04%
		"	CHAN. 5	OXALIC ACD	3-5	4.00	4.35	0.996	0.145	4.48	0.48	11.94%
		"	CHAN. 6	POLYCARB.	4-6	4.90	4.90	0.996	0.145	5.03	0.13	2.56%
		"	CHAN. 7	QUARTZ	32-37	35.10	35.10	1.018	0.325	36.06	0.96	2.73%
		"	CHAN. 8	TEF.PREWGD	32-37	35.30	35.10	1.018	0.325	36.06	0.76	2.14%
		"	CHAN. 9F	TEFLON	32-37	34.80	35.00	1.018	0.325	35.96	1.16	3.32%
		"	CHAN. 9B	QUARTZ	32-37	34.80	35.00	1.018	0.325	35.96	1.16	3.32%
		"	CHAN.10	QUARTZ	32-37	35.30	35.30	1.018	0.325	36.26	0.96	2.72%
		"	CHAN.11	TEF.PREWGD	32-37	34.80	34.95	1.018	0.325	35.90	1.10	3.17%
		"	CHAN.12	TEFLON	32-37	36.40	36.00	1.018	0.325	36.97	0.57	1.57%
		"		DENUDER	3-5							

TABLE 5-2 (CONTINUED)

SCAQS SAMPLER FLOW AUDIT RESULTS

SITE	DATE	SAMPLER	SAMPLER ID	TYPE	NOMINAL FLOW	SCAQMD AUDIT FLOW	ROTAMETER READING	SLOPE	INTERC.	AV FLOW	DELTA	DELTA PERCENT
BURBANK	07/01/87	SCAQS	CHAN. 1	NYLON	9-13	10.30	10.75	0.992	-0.077	10.59	0.29	2.79%
		"	CHAN. 2F	ZFLOUR	20-25	23.50	21.75	1.004	1.655	23.49	-0.01	-0.03%
		"	CHAN. 2B	CARBONATE	20-25	23.50	21.75	1.004	1.655	23.49	-0.01	-0.03%
		"	CHAN. 3	NYLON	8-10	8.40	8.95	0.992	-0.077	8.80	0.40	4.78%
		"	CHAN. 4	NYLON	8-10	8.90	9.55	0.992	-0.077	9.40	0.50	5.58%
		"	CHAN. 5	OXALIC ACD	3-5	4.00	4.30	0.992	-0.077	4.19	0.19	4.72%
		"	CHAN. 6	POLYCARB.	4-6	4.90	5.20	0.992	-0.077	5.08	0.18	3.70%
		"	CHAN. 7	QUARTZ	32-37	35.60	34.25	1.004	1.655	36.04	0.44	1.24%
		"	CHAN. 8	TEF.PREWGD	32-37	36.10	35.00	1.004	1.655	36.80	0.70	1.93%
		"	CHAN. 9F	TEFLON	32-37	34.80	33.50	1.004	1.655	35.29	0.49	1.41%
		"	CHAN. 9B	QUARTZ	32-37	34.80	33.50	1.004	1.655	35.29	0.49	1.41%
		"	CHAN.10	QUARTZ	32-37	35.60	34.50	1.004	1.655	36.29	0.69	1.95%
		"	CHAN.11	TEF.PREWGD	32-37	35.60	34.65	1.004	1.655	36.44	0.84	2.37%
		"	CHAN.12	TEFLON	32-37	35.60	34.90	1.004	1.655	36.69	1.09	3.07%
		"		DENUDER	3-5							
DNTN L.A.	07/10/87	SCAQS	CHAN. 1	NYLON	9-13	10.10	11.00	0.968	0.121	10.77	0.67	6.62%
		"	CHAN. 2F	ZFLOUR	20-25	21.60	23.00	0.958	2.033	24.07	2.47	11.42%
		"	CHAN. 2B	CARBONATE	20-25	21.60	23.00	0.958	2.033	24.07	2.47	11.42%
		"	CHAN. 3	NYLON	8-10	8.80	8.85	0.968	0.121	8.69	-0.11	-1.28%
		"	CHAN. 4	NYLON	8-10	8.30	8.65	0.968	0.121	8.49	0.19	2.34%
		"	CHAN. 5	OXALIC ACD	3-5	4.00	4.10	0.968	0.121	4.09	0.09	2.24%
		"	CHAN. 6	POLYCARB.	4-6	4.70	4.70	0.968	0.121	4.67	-0.03	-0.63%
		"	CHAN. 7	QUARTZ	32-37	31.60	35.75	0.958	2.033	36.28	4.68	14.81%
		"	CHAN. 8	TEF.PREWGD	32-37	31.00	35.25	0.958	2.033	35.80	4.80	15.49%
		"	CHAN. 9F	TEFLON	32-37	30.70	35.00	0.958	2.033	35.56	4.86	15.84%
		"	CHAN. 9B	QUARTZ	32-37	30.70	35.00	0.958	2.033	35.56	4.86	15.84%
		"	CHAN.10	QUARTZ	32-37	30.50	35.00	0.958	2.033	35.56	5.06	16.60%
		"	CHAN.11	TEF.PREWGD	32-37	31.30	36.00	0.958	2.033	36.52	5.22	16.68%
		"	CHAN.12	TEFLON	32-37	32.60	37.50	0.958	2.033	37.96	5.36	16.44%
		"		DENUDER	3-5							

TABLE 5-2 (CONTINUED)

SCAQS SAMPLER FLOW AUDIT RESULTS

SITE	DATE	SAMPLER	SAMPLER ID	TYPE	NOMINAL FLOW	SCAQMD AUDIT FLOW	ROTAMETER READING	SLOPE	INTERC.	AV FLOW	DELTA	DELTA PERCENT
DNTN L.A.	11/09/87	SCAQS	CHAN. 1	NYLON	9-13	8.25	9.25	1.003	-0.075	9.20	0.95	11.55%
		"	CHAN. 2F	ZFLOUR	20-25	23.93	23.00	0.981	1.794	24.36	0.43	1.78%
		"	CHAN. 2B	CARBONATE	20-25	23.93	23.00	0.981	1.794	24.36	0.43	1.78%
		"	CHAN. 3	NYLON	8-10	7.01	7.35	1.003	-0.075	7.30	0.29	4.09%
		"	CHAN. 4	NYLON	8-10	7.50	7.85	1.003	-0.075	7.80	0.30	3.98%
		"	CHAN. 5	OXALIC ACD	3-5	3.85	3.90	1.003	-0.075	3.84	-0.01	-0.35%
		"	CHAN. 6	POLYCARB.	4-6	4.85	4.90	1.003	-0.075	4.84	-0.01	-0.21%
		"	CHAN. 7	QUARTZ	32-37	34.68	35.25	0.981	1.794	36.37	1.69	4.89%
		"	CHAN. 8	TEF.PREWGD	32-37	33.90	34.75	0.981	1.794	35.88	1.98	5.85%
		"	CHAN. 9F	TEFLON	32-37	33.90	34.75	0.981	1.794	35.88	1.98	5.85%
		"	CHAN. 9B	QUARTZ	32-37	33.90	34.75	0.981	1.794	35.88	1.98	5.85%
		"	CHAN.10	QUARTZ	32-37	33.90	34.75	0.981	1.794	35.88	1.98	5.85%
		"	CHAN.11	TEF.PREWGD	32-37	34.68	35.50	0.981	1.794	36.62	1.94	5.59%
		"	CHAN.12	TEFLON	32-37	35.99	37.00	0.981	1.794	38.09	2.10	5.84%
		"		DENUDER	3-5		3.90					
HAWTHORNE	07/10/87	SCAQS	CHAN. 1	NYLON	9-13	10.10	10.45	0.955	0.206	10.19	0.09	0.85%
		"	CHAN. 2F	ZFLOUR	20-25	22.10	22.45	1.026	-0.207	22.83	0.73	3.29%
		"	CHAN. 2B	CARBONATE	20-25	22.10	22.45	1.026	-0.207	22.83	0.73	3.29%
		"	CHAN. 3	NYLON	8-10	8.30	8.55	0.955	0.206	8.37	0.07	0.86%
		"	CHAN. 4	NYLON	8-10	8.80	9.25	0.955	0.206	9.04	0.24	2.72%
		"	CHAN. 5	OXALIC ACD	3-5	4.30	4.40	0.955	0.206	4.41	0.11	2.51%
		"	CHAN. 6	POLYCARB.	4-6	4.70	4.78	0.955	0.206	4.77	0.07	1.51%
		"	CHAN. 7	QUARTZ	32-37	33.40	34.10	1.026	-0.207	34.78	1.38	4.13%
		"	CHAN. 8	TEF.PREWGD	32-37	32.90	34.00	1.026	-0.207	34.68	1.78	5.40%
		"	CHAN. 9F	TEFLON	32-37	32.60	33.80	1.026	-0.207	34.47	1.87	5.74%
		"	CHAN. 9B	QUARTZ	32-37	32.60	33.80	1.026	-0.207	34.47	1.87	5.74%
		"	CHAN.10	QUARTZ	32-37	33.20	34.00	1.026	-0.207	34.68	1.48	4.45%
		"	CHAN.11	TEF.PREWGD	32-37	34.00	35.40	1.026	-0.207	36.11	2.11	6.22%
		"	CHAN.12	TEFLON	32-37	35.10	36.00	1.026	-0.207	36.73	1.63	4.64%
		"		DENUDER	3-5							

TABLE 5-2 (CONTINUED)

SCAQS SAMPLER FLOW AUDIT RESULTS

SITE	DATE	SAMPLER	SAMPLER ID	TYPE	NOMINAL FLOW	SCAQMD AUDIT FLOW	ROTAMETER READING	SLOPE	INTERC.	AV FLOW	DELTA	DELTA PERCENT
LONG BEACH	07/31/87	SCAQS	CHAN. 1	NYLON	9-13	10.60	10.00	0.967	0.124	9.79	-0.81	-7.60%
		"	CHAN. 2F	ZFLOUR	20-25	22.10	20.00	0.995	1.427	21.33	-0.77	-3.50%
		"	CHAN. 2B	CARBONATE	20-25	22.10	20.00	0.995	1.427	21.33	-0.77	-3.50%
		"	CHAN. 3	NYLON	8-10	8.90	9.18	0.967	0.124	9.00	0.10	1.14%
		"	CHAN. 4	NYLON	8-10	8.90	8.92	0.967	0.124	8.75	-0.15	-1.69%
		"	CHAN. 5	OXALIC ACD	3-5	4.10	4.30	0.967	0.124	4.28	0.18	4.44%
		"	CHAN. 6	POLYCARB.	4-6	4.70	4.75	0.967	0.124	4.72	0.02	0.37%
		"	CHAN. 7	QUARTZ	32-37	36.90	34.50	0.995	1.427	35.75	-1.15	-3.10%
		"	CHAN. 8	TEF.PREWGD	32-37	36.40	34.50	0.995	1.427	35.75	-0.65	-1.77%
		"	CHAN. 9F	TEFLON	32-37	35.10	33.50	0.995	1.427	34.76	-0.34	-0.97%
		"	CHAN. 9B	QUARTZ	32-37	35.10	33.50	0.995	1.427	34.76	-0.34	-0.97%
		"	CHAN.10	QUARTZ	32-37	36.10	34.00	0.995	1.427	35.26	-0.84	-2.34%
		"	CHAN.11	TEF.PREWGD	32-37	36.10	34.50	0.995	1.427	35.75	-0.35	-0.96%
		"	CHAN.12	TEFLON	32-37	36.90	35.50	0.995	1.427	36.75	-0.15	-0.41%
		"		DENUDER	3-5							
LONG BEACH	11/09/87	SCAQS	CHAN. 1	NYLON	9-13	9.93	9.75	0.959	0.197	9.55	-0.38	-3.85%
		"	CHAN. 2F	ZFLOUR	20-25	25.24	22.50	1.064	-1.692	22.25	-2.99	-11.85%
		"	CHAN. 2B	CARBONATE	20-25	25.24	22.50	1.064	-1.692	22.25	-2.99	-11.85%
		"	CHAN. 3	NYLON	8-10	8.09	8.45	0.959	0.197	8.30	0.21	2.60%
		"	CHAN. 4	NYLON	8-10	8.13	8.55	0.959	0.197	8.40	0.27	3.28%
		"	CHAN. 5	OXALIC ACD	3-5	4.12	4.25	0.959	0.197	4.27	0.15	3.71%
		"	CHAN. 6	POLYCARB.	4-6	5.08	5.20	0.959	0.197	5.18	0.10	2.04%
		"	CHAN. 7	QUARTZ	32-37	36.52	34.25	1.064	-1.692	34.75	-1.77	-4.85%
		"	CHAN. 8	TEF.PREWGD	32-37	37.30	34.75	1.064	-1.692	35.28	-2.02	-5.41%
		"	CHAN. 9F	TEFLON	32-37	35.99	34.00	1.064	-1.692	34.48	-1.51	-4.18%
		"	CHAN. 9B	QUARTZ	32-37	35.99	34.00	1.064	-1.692	34.48	-1.51	-4.18%
		"	CHAN.10	QUARTZ	32-37	36.52	34.00	1.064	-1.692	34.48	-2.04	-5.58%
		"	CHAN.11	TEF.PREWGD	32-37	35.99	34.25	1.064	-1.692	34.75	-1.24	-3.45%
		"	CHAN.12	TEFLON	32-37	38.35	36.25	1.064	-1.692	36.88	-1.47	-3.84%
		"		DENUDER	3-5							

TABLE 5-2 (CONTINUED)

SCAQS SAMPLER FLOW AUDIT RESULTS

SITE	DATE	SAMPLER	SAMPLER ID	TYPE	NOMINAL FLOW	SCAQMD AUDIT FLOW	ROTAMETER READING	SLOPE	INTERC.	AV FLOW	DELTA	DELTA PERCENT
RUBIDOUX	07/24/87	SCAQS	CHAN. 1	NYLON	9-13	10.10	11.00	0.987	-0.087	10.77	0.67	6.63%
		"	CHAN. 2F	ZFLOUR	20-25	20.20	19.75	0.971	1.666	20.84	0.64	3.18%
		"	CHAN. 2B	CARBONATE	20-25	20.20	19.75	0.971	1.666	20.84	0.64	3.18%
		"	CHAN. 3	NYLON	8-10	8.50	8.95	0.987	-0.087	8.75	0.25	2.90%
		"	CHAN. 4	NYLON	8-10	8.40	8.80	0.987	-0.087	8.60	0.20	2.36%
		"	CHAN. 5	OXALIC ACD	3-5	4.00	4.20	0.987	-0.087	4.06	0.06	1.46%
		"	CHAN. 6	POLYCARB.	4-6	4.50	4.70	0.987	-0.087	4.55	0.05	1.15%
		"	CHAN. 7	QUARTZ	32-37	35.10	34.25	0.971	1.666	34.92	-0.18	-0.50%
		"	CHAN. 8	TEF.PREWGD	32-37	35.90	35.25	0.971	1.666	35.89	-0.01	-0.02%
		"	CHAN. 9F	TEFLON	32-37	34.20	33.75	0.971	1.666	34.44	0.24	0.69%
		"	CHAN. 9B	QUARTZ	32-37	34.20	33.75	0.971	1.666	34.44	0.24	0.69%
		"	CHAN.10	QUARTZ	32-37	35.60	35.00	0.971	1.666	35.65	0.05	0.14%
		"	CHAN.11	TEF.PREWGD	32-37	35.60	35.00	0.971	1.666	35.65	0.05	0.14%
		"	CHAN.12	TEFLON	32-37	35.10	34.00	0.971	1.666	34.68	-0.42	-1.20%
				DENUDER	3-5							
SAN N.IS.	07/21/87	SCAQS	CHAN. 1	NYLON	9-13	9.87	11.00	0.947	0.150	10.57	0.70	7.06%
		"	CHAN. 2F	ZFLOUR	20-25	22.38	23.00	0.983	0.150	22.76	0.38	1.69%
		"	CHAN. 2B	CARBONATE	20-25	22.38	23.00	0.983	0.150	22.76	0.38	1.69%
		"	CHAN. 3	NYLON	8-10	8.47	8.80	0.947	0.150	8.48	0.01	0.16%
		"	CHAN. 4	NYLON	8-10	8.34	9.00	0.947	0.150	8.67	0.33	3.99%
		"	CHAN. 5	OXALIC ACD	3-5	4.21	4.30	0.947	0.150	4.22	0.01	0.29%
		"	CHAN. 6	POLYCARB.	4-6	4.76	4.80	0.947	0.150	4.70	-0.06	-1.35%
		"	CHAN. 7	QUARTZ	32-37	33.71	34.65	0.983	0.150	34.21	0.50	1.49%
		"	CHAN. 8	TEF.PREWGD	32-37	33.44	34.80	0.983	0.150	34.36	0.92	2.75%
		"	CHAN. 9F	TEFLON	32-37	34.25	35.00	0.983	0.150	34.56	0.30	0.89%
		"	CHAN. 9B	QUARTZ	32-37	34.25	35.00	0.983	0.150	34.56	0.30	0.89%
		"	CHAN.10	QUARTZ	32-37	33.98	35.00	0.983	0.150	34.56	0.58	1.69%
		"	CHAN.11	TEF.PREWGD	32-37	35.06	36.00	0.983	0.150	35.54	0.48	1.36%
		"	CHAN.12	TEFLON	32-37	34.79	35.50	0.983	0.150	35.05	0.26	0.74%
		"		DENUDER	3-5							

TABLE 5-3

SUMMARY OF SCAQS SAMPLER FLOW AUDITS

CHANNEL		NOMINAL FLOW	ANA 07/24	AZU 07/01	BUR 07/01	DLA 07/10	DLA 11/09	HAW 07/10	LB 07/31	LB 11/09	RUB 07/24	SNI 07/21
1	NYLON	9-13	3.9	6.8	2.8	6.6	11.6	0.9	-7.6	-3.9	6.6	7.1
2F	ZFLOUR	20-25	0.0	12.5	-0.0	11.4	1.8	3.3	-3.5	-11.9	3.2	1.7
2B	CARBONATE	20-25	0.0	12.5	-0.0	11.4	1.8	3.3	-3.5	-11.9	3.2	1.7
3	NYLON	8-10	-0.8	5.9	4.8	-1.3	4.1	0.9	1.1	2.6	2.9	0.2
4	NYLON	8-10	-0.8	8.0	5.6	2.3	4.0	2.7	-1.7	3.3	2.4	4.0
5	OXALIC ACD	3-5	3.1	11.9	4.7	2.2	-0.4	2.5	4.4	3.7	1.5	0.3
6	POLYCARB.	4-6	-1.8	2.6	3.7	-0.6	-0.2	1.5	0.4	2.0	1.2	-1.4
7	QUARTZ	32-37	-1.4	2.7	1.2	14.8	4.9	4.1	-3.1	-4.9	-0.5	1.5
8	TEF.PREWGD	32-37	0.2	2.1	1.9	15.5	5.9	5.4	-1.8	-5.4	-0.0	2.8
9F	TEFLON	32-37	-0.7	3.3	1.4	15.8	5.9	5.7	-1.0	-4.2	0.7	0.9
9B	QUARTZ	32-37	-0.7	3.3	1.4	15.8	5.9	5.7	-1.0	-4.2	0.7	0.9
10	QUARTZ	32-37	-1.4	2.7	2.0	16.6	5.9	4.5	-2.3	-5.6	0.1	1.7
11	TEF.PREWGD	32-37	-0.6	3.2	2.4	16.7	5.6	6.2	-1.0	-3.5	0.1	1.4
12	TEFLON	32-37	-0.7	1.6	3.1	16.4	5.8	4.6	-0.4	-3.8	-1.2	0.7

Carbonyl Sampler

Results for audits of the carbonyl sampler flow rates are shown in Table 5-4. Results are within reasonable expectations for this sampler, except for the 22 percent difference at Anaheim during the summer study. Also, the ENSR flow rates on average are biased lower than the audit flow rates. These discrepancies have not been resolved, nor have the audit values been incorporated into the calculation of carbonyl concentration.

Aerosol Particle Counters, Impactors and Cyclones

The results of flow rate audits on aerosol particle counters and impactors are shown in Table 5-5.

The results for the EAA and OPC particle counters show reasonable agreement between instrument design flow rates and audit flow rates. However, the results for the PMS Probe showed extreme bias and were discounted. The SCAQMD TSD reported that the PMS Probe flow rates were too low to be accurately audited with the equipment employed during the summer audits. The discrepancy for fall audit results on the Probe was never resolved. The audit results were not reported until after the audit visit, and thus discrepancies could not be discovered and resolved onsite.

Audit results for the MOUDI and Berner impactors showed good agreement with design flow rates. September flow rate audit results for the DRUM Impactor showed such extreme and consistent bias that the audit results were discounted. No probable explanation for the discrepancy has been identified. Audit results were not reported until well after the audit, and thus it was not possible to discover and investigate these discrepancies onsite. However, the University of California, Davis (UCD) had checked the DRUM calibrations onsite before and after the study. During the fall audit, the DRUM audit flow rates were in good agreement with the design flow rates.

TABLE 5-4

CARBONYL FLOW RATE AUDIT RESULTS

SITE	DATE	ENSR FLOW LPM	AUDIT FLOW LPM	DIFF. LPM	DIFF. PERCENT
Anaheim	07/24/87	1.06	1.37	-0.31	-22.6%
Azusa	07/01/87	0.81	0.85	-0.04	-4.7%
Burbank	07/01/87	1.03	1.00	0.03	3.0%
Claremont	08/06/87	0.82	0.77	0.05	6.5%
Hawthorne	07/10/87	0.96	1.10	-0.14	-12.7%
Rubidoux	07/24/87	0.92	1.00	-0.08	-8.0%
San Nicolas Is.	07/21/87	0.93	1.02	-0.09	-8.8%
Anaheim	12/22/87	1.10	1.15	-0.05	-4.3%
Burbank	12/15/87	1.01	1.05	-0.04	-3.8%
DOLA	11/09/87	0.89	0.92	-0.03	-3.3%
Hawthorne	12/15/87	0.91	1.02	-0.11	-10.8%
Long Beach	11/09/87	0.84	0.92	-0.08	-8.7%
Rubidoux	12/22/87	1.05	1.08	-0.03	-2.8%

TABLE 5-5

FLOW RATE AUDIT RESULTS FOR
AEROSOL PARTICLE COUNTERS, CYCLONES, AND IMPACTORS

Site	Date	Instrument Flow	Design Flow (lpm)	Audit Flow (lpm)	Difference From Design (%)
Long Beach	07/31	EAA Aerosol	4.0	4.5	12.5
Rubidoux	08/03	EAA Aerosol	4.0	4.2	5.0
Claremont	08/06	EAA Aerosol	4.0	4.63	15.8
Dola	11/09	EAA Aerosol	4.0	4.21	5.3
Long Beach	11/09	EAA Aerosol	4.0	4.57	14.3
Long Beach	07/31	EAA Total	54.0	55.4	2.6
Rubidoux	08/03	EAA Total	54.0	54.1	0.2
Claremont	08/06	EAA Total	54.0	53.4	1.1
Long Beach	07/31	OPC	7.0	6.8	- 2.9
Rubidoux	08/03	OPC	7.0	6.8	- 2.9
Claremont	08/06	OPC	7.0	6.46	- 7.7
Long Beach	11/09	OPC	7.0	6.51	- 7.0
Long Beach	07/31	Probe	0.06	0.16	[a]
Rubidoux	08/03	Probe	0.06	0.16	[a]
Claremont	08/06	Probe	0.06	0.16	[a]
Dola	11/09	Probe	0.06	17.44	[a]
Long Beach	11/09	Probe	0.06	16.52	[a]
Claremont	09/04	MOUDI	30.0	30.2	0.7
Rubidoux	09/04	MOUDI	30.0	31.8	6.0
Dola	11/09	MOUDI	30.0	30.2	0.7
Long Beach	11/09	MOUDI	30.0	30.2	0.7
Claremont	09/04	Berner	30.0	30.2	0.7
Rubidoux	09/04	Berner	30.0	30.5	1.7
Dola	11/09	Berner	30.0	28.7	- 4.3
Long Beach	11/09	Berner	30.0	28.1	- 6.3
Claremont	09/04	DRUM	1.0	0.22	[a]
Long Beach	09/04	DRUM	1.0	0.22	[a]
Rubidoux	09/04	DRUM	1.0	0.22	[a]
Dola	11/09	DRUM	1.0	1.09	9.0
Long Beach	11/09	DRUM	1.0	1.03	3.0

[a] Audit values are suspect. Subsequent investigations indicate that it is extremely unlikely that audit values are correct as reported.

Audit results for the AIHL and Sensidyne cyclones showed good agreement with design flow rates.

__SSI PM_{10} Hivols__

The SCAQMD TSD calibrated SSI Hivols at Claremont and Long Beach on 6/12/87. The ARB QA Section audited Hivol and SSI Hivol flow rates at Claremont and Downtown Los Angeles on 6/18/87 and 6/16/87, respectively. All results were within 5 percent.

5.3 Nephelometer Audits

The SCAQMD TSD audited the nephelometers installed and maintained by AV at the SCAQS B- and B+-sites. The nephelometers were MRI Model 1560 series adjusted to measure zero for Rayleigh scattering of pure air, and thus measured particle scattering directly. The instruments were spanned by AV with freon-22 and freon-12 to read 0.88 and 1.92 per $10^{-4}m^{-1}$ meters, respectively. AV checked the nephelometers between each intensive period and adjusted them if necessary.

The auditor challenged the instrument with Freon-12. The results are shown in Table 5-6. The results are generally good except at Rubidoux. In this case, the instrument response was noisy, probably due to dust in the light chamber. AV's frequent calibration checks show occasional problems such as that which occurred at Rubidoux during the audit. These occasional problems were routinely caught and corrected between intensive study days.

5.4 Continuous Gas Analyzer Audits

The ARB QA Section conducted audits for the continuous gas analyzers at the SCAQS A and B sites, and those mounted in the STI and UW aircraft. As discussed below, the audits identified a number of problems. To help resolve these problems, calibration

TABLE 5-6

NEPHELOMETER AUDIT RESULTS

Site	Date	Reference Response /1000 m	F-12 Response /1000 m	Zero Response /1000 m	Net Response /1000 m	Diff. (%)
Anaheim	07/24/87	1.92	1.87	0.03	1.84	- 4.2
Azusa	07/23/87	1.92	1.86	- 0.00	1.86	- 3.1
Burbank	07/27/87	1.92	Noisy	0.07	--	--
Claremont	07/23/87	1.92	1.98	0.06	1.92	0.0
DOLA	07/27/87	1.92	1.96	0.09	1.87	- 2.6
Hawthorne	07/27/87	1.92	1.76	- 0.01	1.77	- 7.8
Long Beach	07/24/87	1.92	2.00	0.02	1.98	3.1
Rubidoux	07/24/87	1.92	2.44[a]	0.16[a]	2.28	18.8

[a] Noisy response.

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checks were also provided by ARB Haagen-Smit Laboratories, by SCAQMD, and by STI. The results of the gas analyzer audits are shown in Table 5-7, grouped by monitoring organization.

SCAQMD Sites

The monitoring sites operated by the SCAQMD are audited annually by the SCAQMD QA Section to meet EPA requirements. In addition, a sample of stations is audited by the ARB QA Section each year as a cross check. ENSR reviewed the ARB audit data for 1985, 1986, and 1987, and found generally very good results. Since the SCAQMD sites are ongoing operations with a history of good audit results, the performance audit efforts for SCAQS were focused on the A-sites and the aircraft.

Time was available to audit one SCAQMD site, Los Angeles - North Main, referred to as Downtown Los Angeles (DOLA) during the study. Results for this site were very good during both the summer and fall audits.

General Motors Van

The GM Van was operated at Claremont during the summer study and at Long Beach during the fall. The first audit at Claremont showed good results for O_3, but poor results for NO_2, SO_2, CO, and THC. The poor results were confirmed by a second audit a few days later and again by Haagen-Smit Laboratory. The differences were eventually traced to problems with the calibration system, that were subsequently corrected by GM. Later audits of the GM van at Claremont by the SCAQMD and at Long Beach by the ARB QA Section showed good results for NO_2 and CO.

The early data, collected by GM during the period of faulty calibration, have since been corrected to reflect the best available estimates of calibration values. Applying these

TABLE 5-7

GAS ANALYZER PERFORMANCE AUDIT RESULTS

SITE GROUP	DATE	O3 audit value ppb	O3 site value ppb	O3 diff %	CO audit value ppm	CO site value ppm	CO diff %	NO2 audit value ppb	NO2 site value ppb	NO2 diff %	SO2 audit value ppb	SO2 site value ppb	SO2 diff %	THC audit value ppm	THC site value ppm	THC diff %	CH4 audit value ppb	CH4 site value ppb	CH4 diff %
DOLA	6/16/87	407	395	-2.9	38.6	39.8	3.1	390	354	-9.2	399	374	-6.3	16.9	17.3	2.4	16.9	18.0	6.5
SCAQMD		180	175	-2.8	18.2	19.1	4.9	175	156	-10.9	188	181	-3.7	6.8	6.6	-2.9	6.8	7.4	8.8
		74	70	-5.4	7.4	7.8	5.4	70	68	-2.9	76	76	0.0						
			avg diff	-3.7		avg diff	4.5		avg diff	-7.6		avg diff	-3.3		avg diff	-0.3		avg diff	7.7
DOLA	11/19/87																		
SCAQMD																			
			avg diff	-9.9		avg diff	4.9		avg diff	1.4		avg diff	3.4		avg diff	6.0		avg diff	4.3
CLARE	6/18/87	400	388	-3.0		not ready		174	113	-35.1	49	38	-22.4	4.5	6.3	39.1			
GM		176	167	-5.1				65	43	-33.8									
		74	70	-5.4															
			avg diff	-4.5					avg diff	-34.5		avg diff	-22.4		avg diff	-39.1			
CLARE	6/27/87				38.7	13.9	-64.1	175	128	-26.9	78	59	-24.4						
GM					19.5	9.6	-50.8	64	47	-26.6	41	30	-26.8						
						avg diff	-56.1		avg diff	-26.7		avg diff	-25.6						
CLARE	7/3/87							0	1	--									
GM								410	263	-35.9									
Audit of NOX not NO2								233	143	-38.6									
by Haagen Smit								116	65	-43.5									
								56	31	-44.6									
									avg diff	-40.6									
CLARE	9/4/87				45.0	40.1	-10.9	0	0	--									
GM					40.0	35.9	-10.3	216	210	-2.8									
Audit of CO and					30.0	27.0	-10.0	160	154	-3.8									
NO2 by SCAQMD					20.0	18.1	-9.5	98	94	-4.1									
					10.0	9.1	-9.0	28	26	-7.1									
						avg diff.	-9.9		avg diff	-4.5									
L.B.	11/17/87				39.5	37.9	-4.1	180	179	-0.6									
GM					18.6	18.1	-2.7	72	71	-1.4									
					6.6	6.7	1.5												
						avg diff	-1.7		avg diff	-1.0									

TABLE 5-7 (CONTINUED)

GAS ANALYZER PERFORMANCE AUDIT RESULTS

Site Group	date	O3 audit value ppb	O3 site value ppb	O3 diff %	CO audit value ppm	CO site value ppm	CO diff %	NO2 audit value ppb	NO2 site value ppb	NO2 diff %	SO2 audit value ppb	SO2 site value ppb	SO2 diff %	THC audit value ppm	THC site value ppm	THC diff %	CH4 audit value ppb	CH4 site value ppb	CH4 diff %
L.B.	6/17/87	402	387	-3.7	38.4	38.7	0.8	388	369	-4.9	397	480	20.9						
ARB		174	166	-4.6	18.3	16.6	9.3	172	163	-5.2	189	236	24.9						
		74	70	-5.4	7.5	7.0	-6.7	55	48	-12.7	78	102	30.8						
			avg diff	-4.6		avg diff	-5.1		avg diff	-7.6		avg diff	25.5						
L.B.	11/17/87	397	390	-1.8	39.1	38.9	-0.5	377	418	10.9	384	563	46.4						
ARB		180	178	-1.1	18.3	18.0	-1.6	176	194	10.2	180	217	20.6						
		72	72	0.0	6.6	6.3	-4.5	70	77	10.0	65	76	16.9						
			avg diff	-1.0		avg diff	-2.2		avg diff	10.4		avg diff	28.0						
AIRCRAFT	6/22/87	395	381	-3.5				401	371	-7.5	73	73	0.0						
STI		165	158	-4.2				166	147	-11.4									
		70	68	-2.9				60	47	-21.7									
			avg diff	-3.5					avg diff	-13.5		avg diff	0.0						
AIRCRAFT	11/15/87																		
STI			avg diff	12.7					avg diff	10.0									
AIRCRAFT	6/23/87	161	168	4.3	38.5	37.2	-3.4	164	292	78.0	44	63	43.2						
UW		61	107	75.4	17.9	17.3	-3.4	32	68	112.5									
					4.3	4.3	0.0												
			avg diff	39.9		avg diff	-2.2		avg diff	95.3		avg diff	43.2						
AIRCRAFT	6/26/87	179	346	93.8				170	308	81.2	93	138	48.4						
UW		99	179	80.8				66	122	84.8	45	61	35.6						
		47	90	91.5							24	39	62.5						
			avg diff	88.5					avg diff	83.0		avg diff	48.8						
AIRCRAFT	7/27/87	257	525	104.3				245	530	116.3	61	130	131.1						
UW		186	440	136.				184	420	128.3	46	100	117.4						
Audit of NOX		125	290	132.0				123	240	95.1	30	86	186.7						
not NO2. Audit		59	130	120.3				61	120	96.7	15	53	253.3						
by STI.		32	65	103.1															
			avg diff	119.2					avg diff	109.1		avg diff	172.1						

recalibrations to the audit data led to good agreement with audit concentrations.

ARB Haagen-Smit Laboratory

Audits at the ARB Haagen-Smit site in Long Beach show good results for O_3, CO, and NO_2, but a consistent bias for SO_2. These results hold true during both summer and fall audits. The discrepancy for SO_2 was traced to a problem with the calibration span gas and the data have been corrected to reflect the correct span values.

Sonoma Technology Aircraft

The audit results for the STI Aircraft are within the ARB tolerance limits of 15 percent for average percent difference. However, there are moderate discrepancies. STI investigated the discrepancies and confirmed the existing calibrations. The source of the discrepancies could not be determined.

University of Washington Aircraft

Audits of the UW aircraft showed problems for O_3, NO_2, and SO_2. A follow-up audit by the ARB QA section and a calibration check by STI confirmed the problems. UW investigated the calibrations and resolved all discrepancies. The following explanations are discussed more fully in Hegg and Hobbs (1988).

For NO_2, an error in permeation tube calculations was corrected, and the calibration range was extended. UW reports that after these adjustments were made, the audit differences for NO_2 were less than 10 percent.

For SO_2, repeated gravimetric determinations of calibrator permeation rate demonstrated that the permeation rate was erratic. The value used to calibrate for the SCAQS study was changed to a value measured during the study. UW reports that after this adjustment, the audit differences for SO_2 were less than 12 percent.

For O_3, the audit difference was traced to an erroneously calibrated O_3 generator. The O_3 generator was then calibrated against a secondary standard calibrated by the Department of Energy (DOE). UW reports that after applying the new calibration data to the audit data, the audit differences were less than 10 percent.

5.5 Meteorological Audits

The ARB QA Section performed simple checks on meteorological instrumentation. These audits were not intended to provide precise quantitative data. Instead, they were intended to detect major malfunctions and misadjustments, such as a wind direction sensor 180 degrees out of alignment. Wind direction was checked with a hand-held compass, wind speed was checked with a hand-held anemometer, temperature with a traceable thermometer, and humidity with a battery-operated psychrometer. The audit results are shown in Table 5-8. These results show that all instruments were functioning well.

Small to moderate biases were observed for wind speed, wind direction, and temperature. The auditor noted that audit temperature readings at several sites were probably high, since they were taken approximately 5 feet above surfaces such as hot asphalt roofs rather than at tower height. Wind direction averages about 10 degrees lower than audit values (i.e. station north points east of audit true north). This may reflect a discrepancy in magnetic corrections, which are about 15 degrees. The bias in wind speed has been explored. This comparison is based on the auditor visually averaging the station response and the audit device response to varying wind speeds, and does not warrant quantitative conclusions. It appears that if the audit device were reading miles per hour instead of knots, the bias might be reduced. The audit device is able to read in knots, miles per hour, or meters

TABLE 5-8

PERFORMANCE AUDIT RESULTS FOR METEOROLOGICAL MEASUREMENTS

SITE	DATE	WIND DIRECTION DEGREES		WIND SPEED KNOTS		TEMPERATURE DEGREES CELSIUS		HUMIDITY/DEW POINT % / DEG. F	
		SITE RESPONSE	CHECK DEVICE	SITE RESPONSE	CHECK DEVICE	SITE RESPONSE	CHECK DEVICE	SITE RESPONSE	CHECK DEVICE
CLAREMONT MCKENNA	6/18/87	270	280	6.2	7.5	25.2	25.6	30%	29%
ANAHEIM	6/19/87	0	10	3.5	4.0	16.7	18.5	52	56
BURBANK	6/19/87	0	5	5.2	5.5	25.0	27.2	52	52
AZUSA	6/19/87	0	12	5.6	6.0	25.3	29.4	53.5	53
HAWTHORNE	6/19/87	0	<5	3.5	4.5	20.2	21.1	54.8	57
SONOMA TECHNOLOGY N6670Y	6/22/87					31.6	31.5		
RUBIDOUX	6/24/87	0	15	2.6	4.0	16.8	18.0	57.1	58.4

KLK 9/17/87

Blanks indicate no instrument

per second. The auditor states that he recorded audit device readings as knots. The possibility of a mixup exists, but cannot be confirmed.

6. SPECIAL STUDIES AND INTERCOMPARISONS

6.1 Nitrogen and Carbonaceous Species Methods Comparison Studies

Two comprehensive field and laboratory comparison studies, the Nitrogen Species Methods Comparison Study (NSMCS) and the Carbonaceous Species Methods Comparison Study (CSMCS), were coordinated by ARB to facilitate the planning for SCAQS. The objectives of the studies were to quantify differences among sampling methods and to assess the magnitude of specific types of sampling artifacts.

The NSMCS was conducted in September 1985 at Pomona College in Claremont, California. Its main objective was to evaluate methods for sampling nitric acid and other nitrogenous pollutants such as ammonia, nitrous acid, and nitrogen dioxide during SCAQS (Lawson, et al. 1988). Results from the NSMCS showed that the diffusion denuder method and diffusion tube, two routine monitoring methods, were nearly equivalent to spectroscopic methods for the measurement of nitric acid and ammonia, respectively. Results were inconclusive for the other species, so redundant measurements using a variety of techniques were included in SCAQS.

The CSMCS was conducted in August 1986 at Citrus College in Glendora, California. The objectives were to evaluate analytical methods for measurement of total "organic" and "elemental" carbon on a suite of 20 separate samples by means of an interlaboratory round robin (Hering 1988). Regression analyses performed by ARB staff (Lawson 1989a) showed that the carbon analysis method employed by ENSR was closest to the mean of all the methods for the three carbon components. Inasmuch as no NBS-traceable standards are available for total "organic" and "elemental" carbon particles, the Coordinating Research Council (CRC), upon recommendation from ARB, decided to fund ENSR to provide analysis of the SCAQS sampler filters for carbon.

During the CSMCS, a formaldehyde methods evaluation study was carried out (Lawson, et al. 1989b) in order to evaluate formaldehyde measurement techniques. The Fourier transform infrared (FTIR), differential optical absorption spectroscopy (DOAS), tunable diode laser absorption spectrometer (TDLAS), diffusion scrubber, enzymatic method, and dinitrophenolhydrazine (DNPH) cartridges were evaluated, and the DNPH method was chosen. All reported values averaged less than 20 percent from the mean of the three spectroscopic methods (FTIR, DOAS, and TDLAS).

A hydrogen peroxide sampling methods evaluation was also conducted during the CSMCS (Lawson 1989c). The TDLAS, diffusion scrubber, impinger, enzymatic technique, and cold trap U-tube were evaluated, and considerable difference among methods was shown. The difference among methods was greater than the experimental error of the methods, with no conclusion regarding a method which would be accurate and suitable for routine measurement of H_2O_2 during SCAQS. However, after considerable evaluation by ARB and staff and CRC members, CRC chose to fund the TDLAS and impinger methods for H_2O_2 measurement during SCAQS. Both the formaldehyde and hydrogen peroxide evaluations were conducted without the use of suitable reference standards.

Evaluation of sampling and analytical methods in NSMCS and CSMCS served as an initial phase of QA for SCAQS.

6.2 Precision Test of SCAQS Sampler

Prior to the field study, AV operated all ten SCAQS samplers side-by-side to verify equivalency and to determine precision of results. The sampling was conducted between June 3 and June 7, 1987 at the AV facility in Monrovia. Pollutant concentrations were unusually low during the evaluation, resulting in loadings near or below detection limits for low flow filters. When the loadings were sufficiently above the overall detection limit, the coefficients of variation were between 5 percent and 10 percent. For very low loadings, the coefficients of variation were generally less than the percent overall detection limits. The details of the precision tests and results are documented in a report prepared by Fitz and Savicker (1988).

6.3 SCAQS Comparison Studies

In addition to the performance audits described in Sections 4 and 5, ARB coordinated comparison studies for elemental analysis, speciated hydrocarbons, light absorption and PAN due to the difficulty of defining performance audit procedures for these measurements. The results of the comparison studies are summarized below. Data submitted by each participating laboratory are compiled in Appendices B, C, D, E, and F.

6.3.1 Elemental Analysis

Sixteen Teflon filters (two duplicate sets of three $PM_{2.5}$ and three PM_{10} samples plus two duplicate sets of one $PM_{2.5}$ and one PM_{10} field blanks) were analyzed by wavelength dispersive XRF at EPA/NSI (SCAQS laboratory), NEA, Inc., and the Monitoring and Laboratory Division of ARB. The collocated samples were collected with the prototype SCAQS aerosol sampler in Monrovia, California between March 26, 1987 and April 8, 1987. One sample from each pair was later analyzed by wavelength dispersive XRF at Desert Research Institute (DRI) followed by Instrumental Neutron Activation Analysis (INAA) at the University of Maryland. Five of the second set of filters were analyzed by particle induced x-ray emission (PIXE) at UCD. A set of eight single elements (aluminum, silicon, potassium, calcium, vanadium, iron, copper, and lead) Micromatter standards and two multi-element NBS standards were analyzed by NSI. The SRMs were previously analyzed by DRI as part of QA for the Denver Brown Cloud Study.

Results of analysis of XRF SRMs by NSI were in excellent agreement with the reference values (Table 6-1). With one exception, the differences were within 10 percent of the reference values.

The scatter diagrams in Figure 6-1 show that NEA obtained higher values than EPA/NSI for soil related elements in coarse particles, while excellent agreement was obtained for sulfur which is found mostly in fine particles. Similar differences were found between ARB and EPA/NSI. Sample nonuniformity was suspected as the cause since a 1-cm^2 area in the center of the filter is exposed by both NEA and ARB while nearly the entire deposit area (3-cm diameter) is exposed by NSI. Visual evidence of nonuniformity was reported by DRI in samples collected with the SCAQS Sampler (Chow 1988).

In order to investigate the degree of nonuniformity, five of the comparison samples were sent to UCD and scanned by PIXE edge-to-edge to establish the element-specific gradients. The PIXE scan shown in Figure 6-2 confirms that particles collected with the SCAQS Sampler, as originally designed, are not uniformly deposited. A limited comparison of NSI's XRF results with the average of the PIXE scans showed good agreement in some cases but differences in others. These comparisons show that the large area of exposure used by NSI will average out much of the spatial inhomogeneity in the sample. However, the result may not be the true average because the x-ray beam intensity is not uniform (Kellogg 1989). In order to investigate this question, six of the comparison samples were analyzed by INAA at the University of Maryland, and the results were compared to the XRF analyses. The comparisons for iron and aluminum are shown in Table 6-2. NSI's values for aluminum are generally in good agreement with the INAA data while iron values are consistently higher by 16 to 37 percent for $PM_{2.5}$ and by 42 to 59 percent for PM_{10}. Uncertainties in the data were high for the other elements due to concentrations near or below detection limits and relatively high blank values.

TABLE 6-1

ANALYSIS OF STANDARD REFERENCE MATERIALS FOR XRF
NSI

XRF SRMs	Certified $\mu g/cm^2$	± $\mu g/cm^2$	Conc. $\mu g/cm^2$	2-sigma $\mu g/cm^2$	Diff.	Diff. (%)
NBS 1832-1417						
Aluminum	14.26	.95	15.13	.80	.87	6.1
Silicon	33.27	1.11	31.79	1.63	-1.48	-4.4
Calcium	19.01	1.27	19.30	.97	.29	1.5
Vanadium	4.60	.48	4.18	.23	- .42	-9.1
Manganese	4.44	.48	4.87	.39	.43	9.7
Cobalt	1.00	.06	.97	.07	- .03	-3.0
Copper	2.38	.16	2.18	.13	- .20	-8.4
NBS 1833-977						
Silicon	32.14	2.12	30.97	1.59	-1.17	-3.6
Potassium	16.98	1.67	15.99	.80	- .99	-5.8
Titanium	12.73	1.82	13.16	.66	.43	3.4
Iron	14.10	.46	14.25	.75	.15	1.1
Zinc	3.94	.30	3.74	.21	- .20	-5.1
Lead	16.22	.76	15.13	.78	-1.09	-6.7
MicroMatter						
Aluminum	17.00	.85	17.13	.86	.13	.8
Silicon	10.19	1.02	8.44	.43	-1.75	-17.2
Copper	36.00	1.80	34.26	1.72	-1.74	- 4.8
Sulfur	19.00	.95	17.32	.87	-1.68	- 8.8
Calcium	12.32	.62	11.22	.56	-1.10	- 8.9
Potassium	2.31	.23	2.21	.11	- .10	- 4.3
Vanadium	13.00	1.30	12.24	.62	- .76	- 5.8
Iron	12.00	1.20	12.77	.65	.77	6.4
Lead	9.00	.90	8.07	.41	- .93	-10.3

1200-004-001

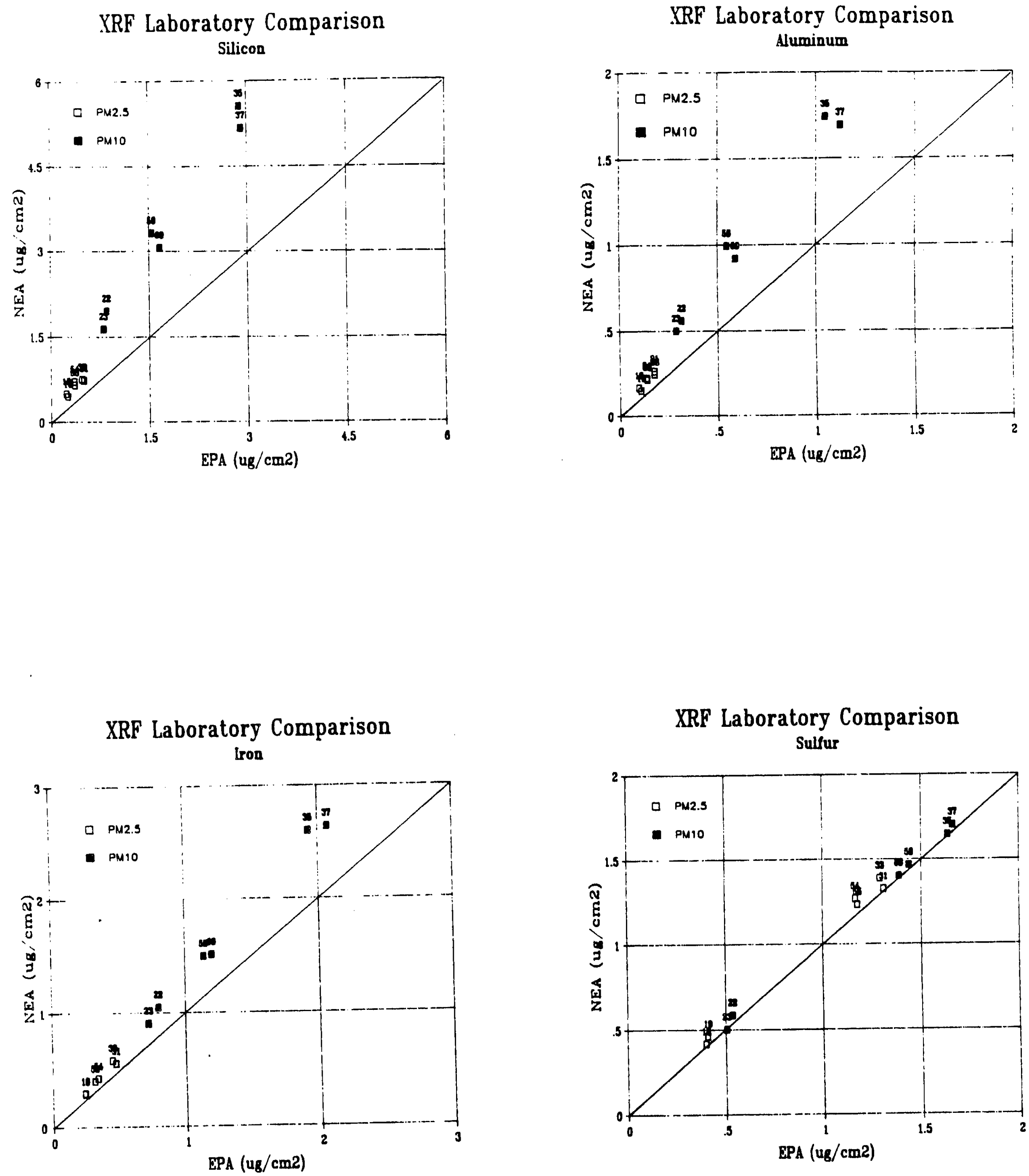

Figure 6-1. Scatter diagram of XRF measurements of silicon, aluminum, iron, and sulfur concentrations by NEA and EPA/NSI.

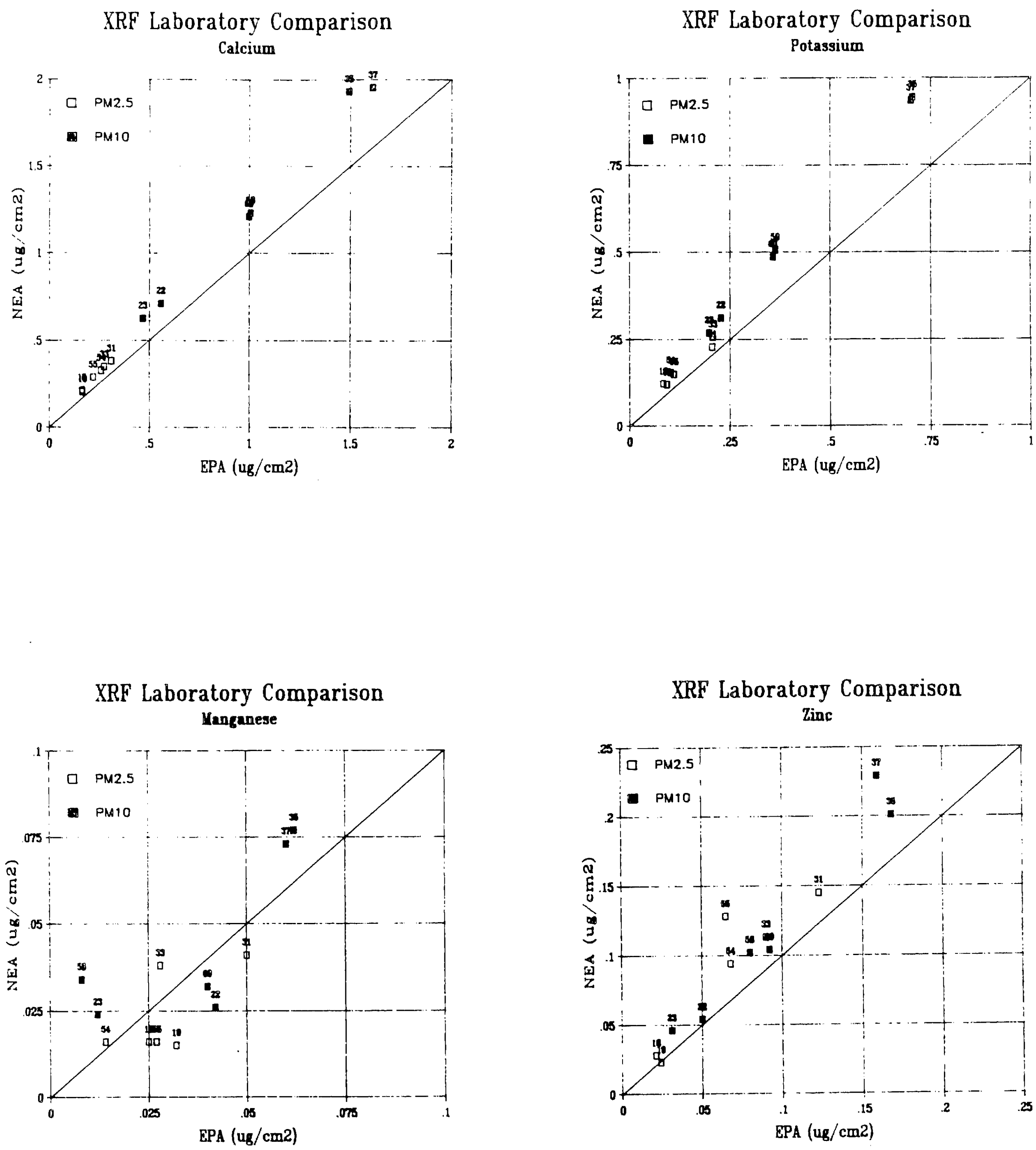

Figure 6-1 (Continued). Scatter diagram of XRF measurements of calcium, potassium, manganese, and zinc concentrations by NEA and EPA/NSI.

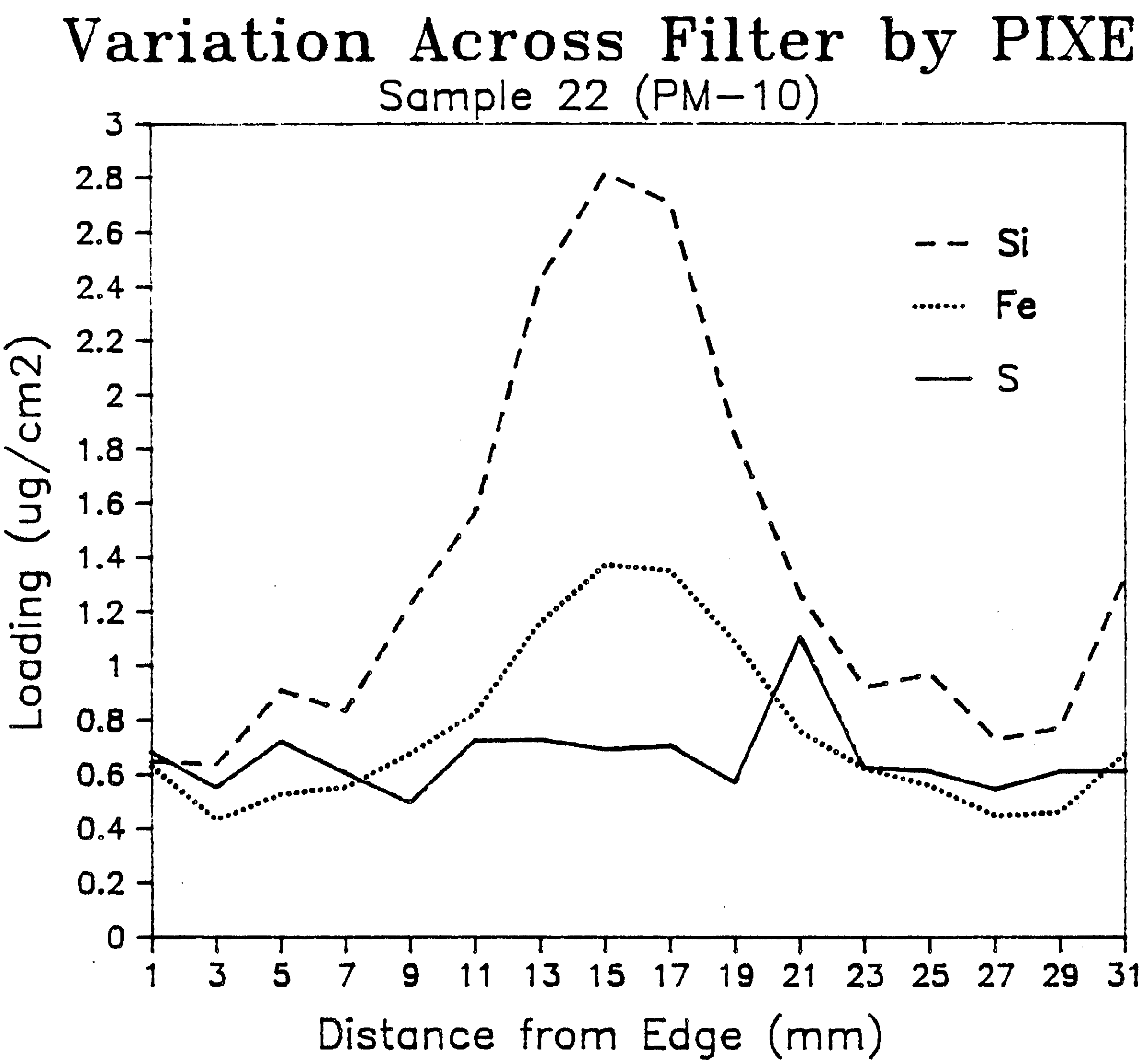

Figure 6-2. PIXE measurement of concentration gradient across the filter by UCD.

TABLE 6-2

Analysis of Iron and Aluminum by XRF and INAA

Element Size, um	ID #	EPA XRF ug/fil	UM INAA ug/fil	DRI XRF ug/fil	NEA XRF ug/fil	ARB XRF ug/fil	EPA/ UM	EPA/ mean XRF
Aluminum								
<2.5	19	1.01 ± .04	1.15 ± .15	1.08 ± .08	1.27 ± .22		.88	.86
<2.5	31	1.67 ± .06	1.80 ± .22	1.70 ± .10	2.38 ± .38		.93	.82
<2.5	54	1.29 ± .05	2.35 ± .30	2.17 ± .10	1.98 ± .32		.55	.62
<10	23	2.76 ± .09	3.40 ± .45	8.25 ± 2.51	3.89 ± .72		.81	.45
<10	35	10.05 ± .27	8.90 ± 1.00	28.56 ± 8.47	15.81 ± 2.51		1.13	.45
<10	58	5.26 ± .15	5.70 ± .70	17.95 ± 5.35	8.64 ± 1.44		.92	.40
Iron								
<2.5	19	2.29 ± .12	1.98 ± .28	2.34 ± .02	2.67 ± .15	2.37	1.16	.93
<2.5	31	4.55 ± .18	3.38 ± .35	4.39 ± .03	5.24 ± .27	4.22	1.35	.99
<2.5	54	3.25 ± .15	2.55 ± .33	3.40 ± .02	4.00 ± .21	3.19	1.28	.92
<10	23	6.94 ± .24	4.90 ± .45	6.40 ± .03	7.58 ± .44	6.57	1.42	1.01
<10	35	18.55 ± .53	12.20 ± .75	20.74 ± .06	23.87 ± 1.26	20.45	1.52	.86
<10	58	10.97 ± .35	6.90 ± .60	10.24 ± .04	13.23 ± .73	10.28	1.59	.98

Concentrations are corrected for field blanks.

Uncertainties are ± 1 standard deviation.

Additional ongoing activities include comparisons of the XRF data from the SCAQS samples with PIXE data from UCD's DRUM and IMPROVE samplers, which were operated concurrently at several sites, and PIXE scans of a subset of SCAQS samples. The PIXE scans will be used to determine whether it is necessary to adjust the XRF data and whether a constant factor can be used.

6.3.2 Speciated Hydrocarbons

Three ambient air samples were provided by the Oregon Graduate Center (OGC) and were analyzed by GC at EPA's AREAL and at OGC. At EPA, the samples were analyzed by L. Stockburger of the Heterogeneous Chemistry and Aerosol Research Branch [EPA(S)], and by W. Lonneman of the Gas Phase Photochemistry Branch [EPA(L)]. The samples were analyzed a minimum of three times by each laboratory in round-robin fashion over a course of 6 months. The samples were also analyzed once at Washington State University. The SCAQS samples were analyzed by EPA(S) for C_4-C_{10} hydrocarbons and by OGC for C_2 and C_3 hydrocarbons due to the poor resolution of C_2 and C_3 compounds by the EPA(S) system. QA included reanalysis of 60 SCAQS samples by GC/MS and a study of the effect of sample storage by EPA(S). Results of the sample storage study are documented elsewhere (Stockburger 1989). In addition, 10 percent of the SCAQS samples were reanalyzed by OGC and 24 samples were reanalyzed by EPA(L).

Results of the laboratory comparison for speciated hydrocarbon analysis were within acceptable ranges. The scatter diagrams in Figure 6-3 show that the values reported by the SCAQS laboratory, EPA(S), are within 8 percent of the mean of all the laboratories. Figure 6-4 shows that the coefficients of variation among the four laboratories are generally within 10 percent when the concentration is above 5 ppbC. Hydrocarbons with apparent identification problems were deleted from the comparison. Such hydrocarbons accounted for 10 to 15 percent of the total concentration. The most common problem was the varying ability among the laboratories

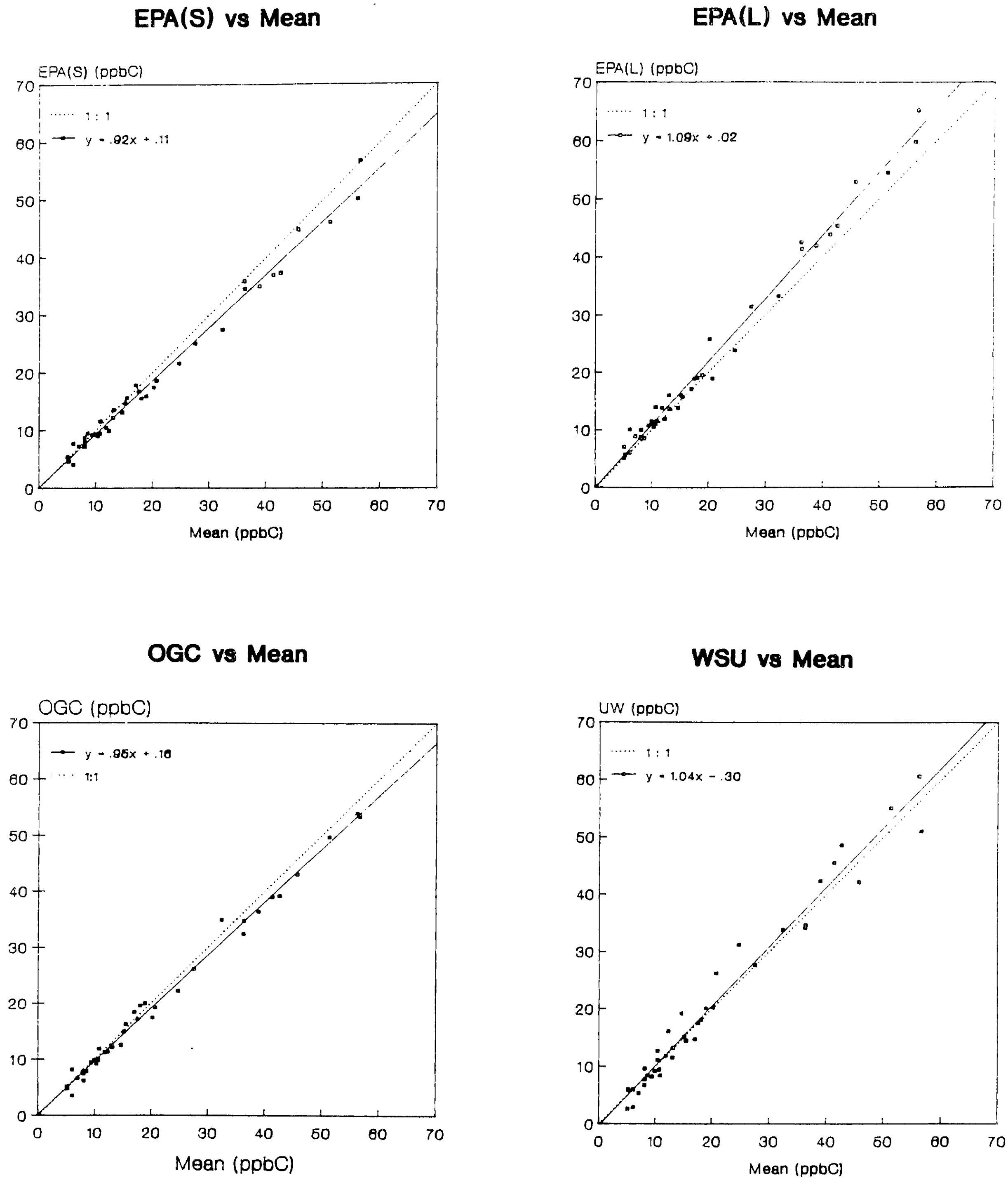

Figure 6-3. Scatter diagram of hydrocarbon concentrations (> 5 ppbC) measured by each laboratory versus the mean.

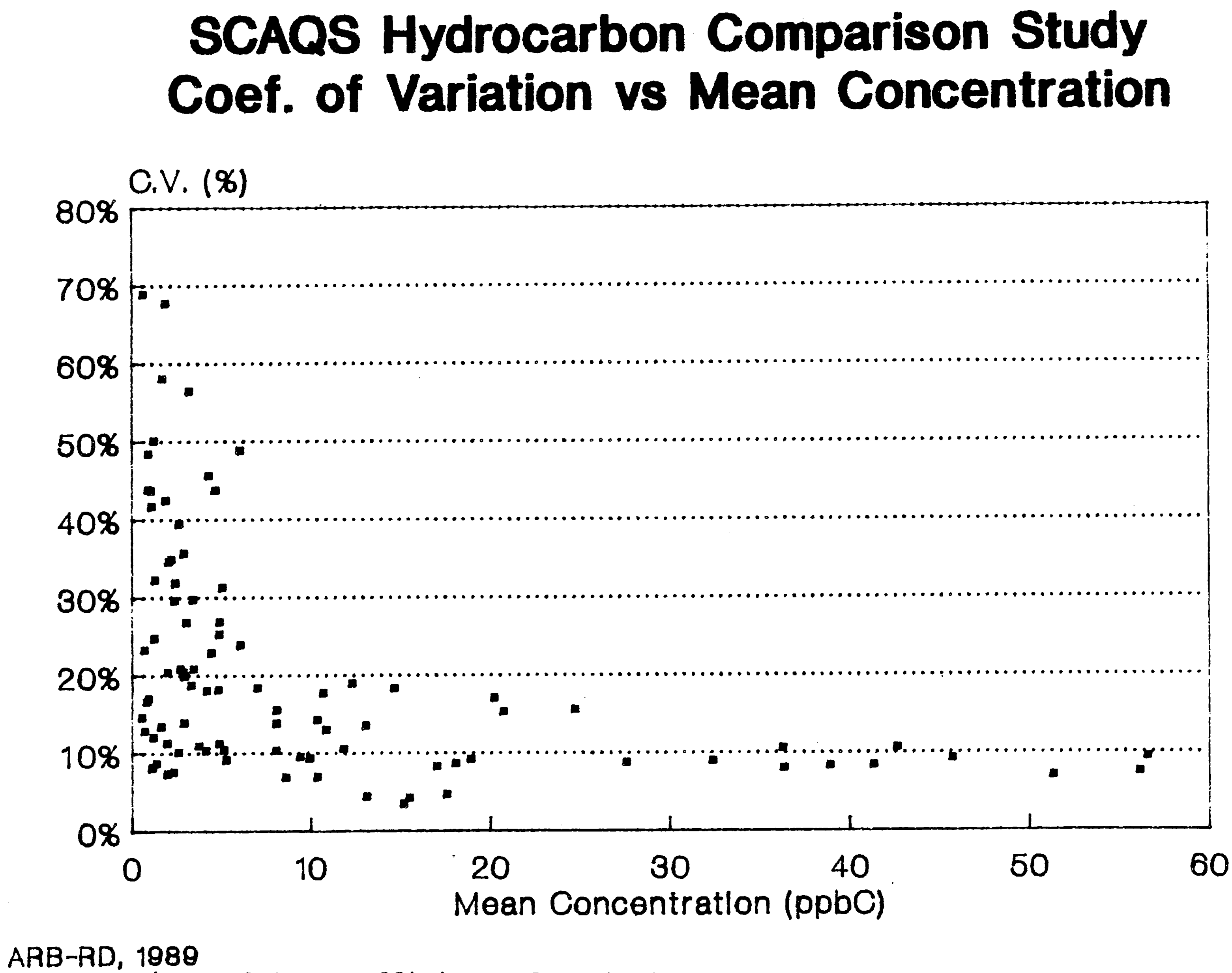

Figure 6-4. Coefficient of variation versus mean concentration.

to resolve closely spaced peaks in the chromatogram. The percentage of the total concentration of hydrocarbons identified and the coefficients of variation for individual and various sums (includes all data) by functional groups are given in Table 6-3.

The data originally reported by OGC in units of ppbC were adjusted by a factor of 1.13. The adjustment was made to normalize the ug/m^3 to ppbC conversion to propane.

6.3.3 Light Absorption

Optical extinction by absorption (b_{abs}) was measured on the SCAQS polycarbonate filters by Radiance Research using the Integrating Plate Method (IPM). The filters were originally analyzed at UCD by IPM. Uncertainties in the UCD data were high due to the lack of prior tare measurements and excessive variability in the transmittance of blank filters. Radiance Research was able to improve the accuracy of the measurement by using the unsampled edge of each filter to make the unsampled tare. Most of the filters contained what appeared to be oil spots. Transmittance was measured within areas unaffected by the spots. Light absorption data for 40 SCAQS samples were correlated against concentrations of elemental carbon reported by ENSR for the corresponding time periods.

A scatter diagram of b_{abs} measured by Radiance Research versus elemental carbon concentration measured by ENSR is shown in Figure 6-5. A factor of 0.8 has been applied to b_{abs} data to correct for the positive artifact associated with the use of Nuclepore filters. The resulting correlation coefficient (0.9) and absorption coefficient per unit mass (10.8 m^2/g) are very reasonable.

TABLE 6-3

SCAQS HYDROCARBON COMPARISON STUDY

C_4 - C_9 Hydrocarbons	Sample 108	Sample 109	Sample 146
Coefficient of Variation (%) Individual HCs > 5 ppbC	10.6 ± 4.9	9.9 ± 3.7	11.2 ± 5.1
Total Paraffins	11.6	13.2	9.6
Total Olefins	32.3	22.8	50.6
Total Aromatics	13.6	5.8	12.3
Total Identified	11.2	8.0	10.0
Total (Including Unknowns)	9.7	8.1	9.3
Mean % Identified	86.2	89.7	85.4

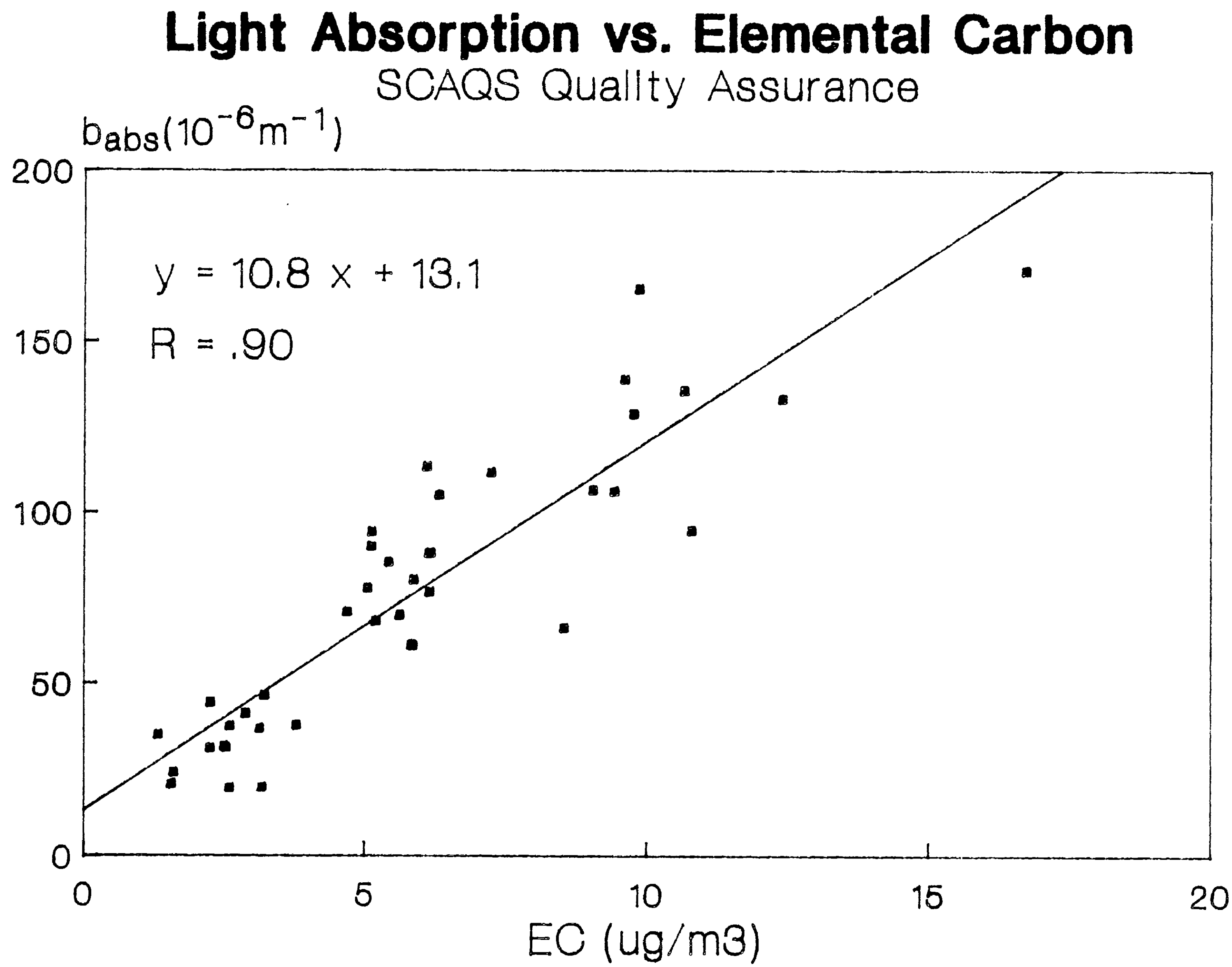

Figure 6-5. Scatter diagram of light absorption measured by Radiance Research versus elemental carbon concentrations measured by ENSR.

6.3.4 Peroxyacetyl Nitrate

Several informal measurement comparisons were arranged by DGA, Inc. (DGA) during the summer field study. Measurements of the diluted outputs of the DGA PAN generator by DGA (EC-GC) were compared separately with side-by-side measurements made by General Motors Research Laboratory (EC-GC), University of Denver (Luminol-GC), and EPA (EC-GC). Ambient measurements of PAN during the summer field study by DGA, UCD, and EPA were also compared. Side-by-side measurements of the PAN generator outputs were made during the fall study by DGA and Unisearch Associates, Inc (Luminol-GC). A comparison of calibration methods was conducted at EPA in Research Triangle Park, North Carolina in September 1988 to resolve the difference between the ambient PAN measurements by EPA and DGA.

The time-series plot in Figure 6-6 of ambient measurement of PAN by DGA and EPA shows good correlation (i.e. good precision) but a consistently large bias (i.e. poor accuracy). The relative difference as a function of concentration is shown in Figure 6-7. The mean relative difference for concentrations above 5 ppb is 28.3 ± 11.6 percent. A comparison of the alkaline hydrolysis method of calibration used by DGA and the FTIR method used by EPA showed no significant difference between methods. DGA reports a relative measurement uncertainty of 11 to 50 percent with typical values in the range of 13 to 18 percent. Results of the comparison studies for PAN are documented in a report prepared by Daniel Grosjean Associates (1989).

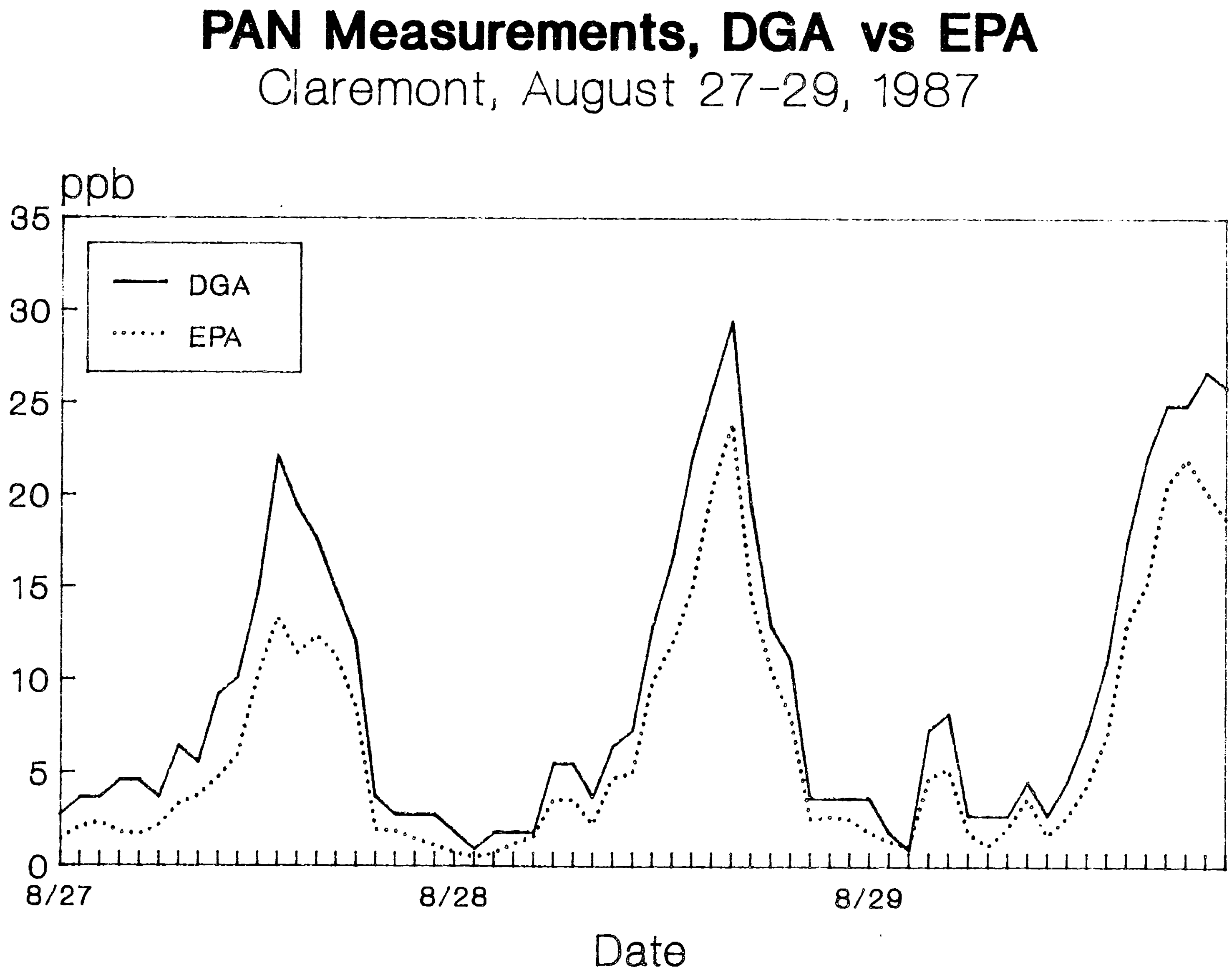

Figure 6-6. Ambient measurement of PAN by DGA and by EPA during SCAQS.

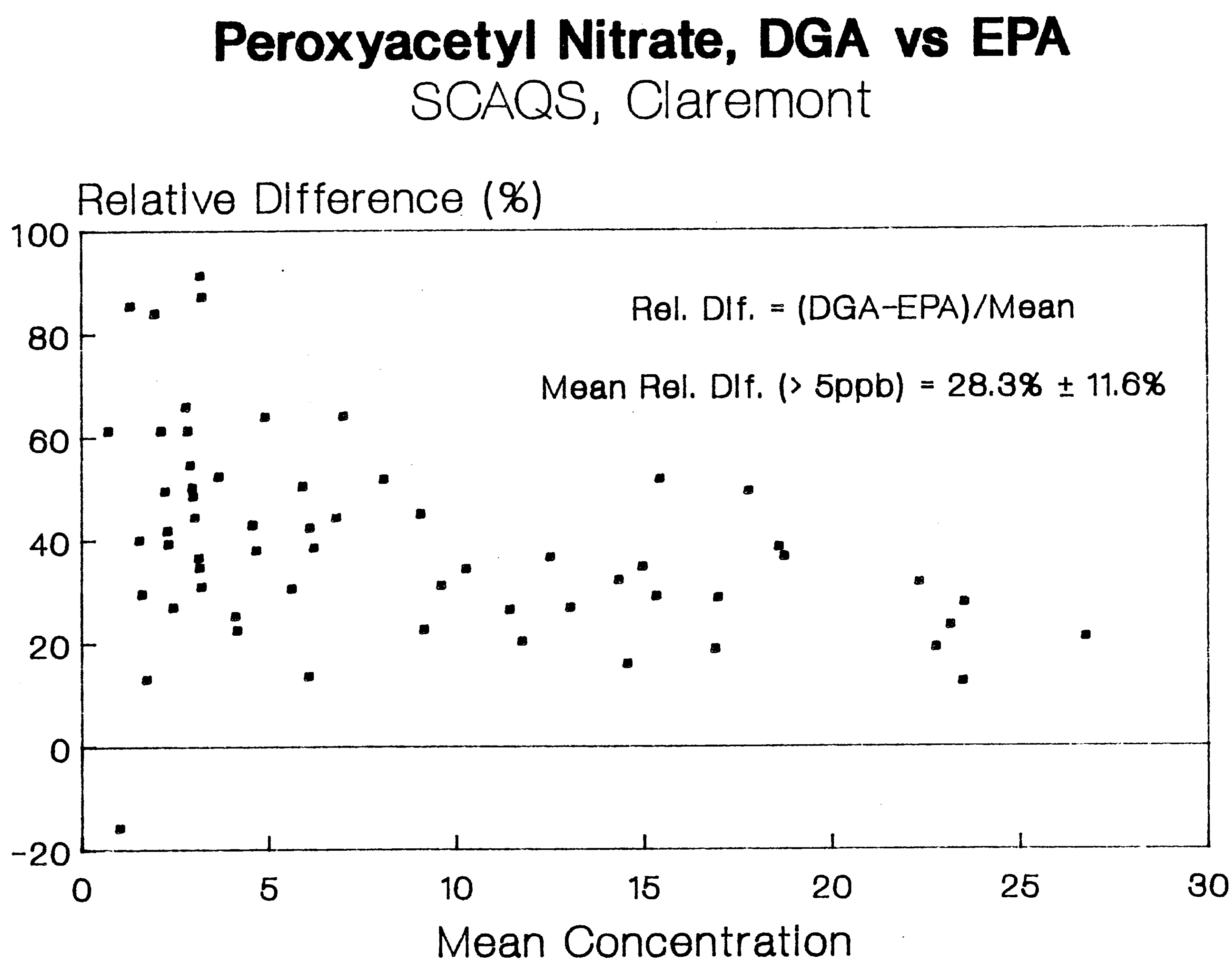

Figure 6-7. Relative difference of PAN measurements by DGA and by EPA versus mean concentration.

7. MEASUREMENT ACCURACY AND PRECISION

The SCAQS Data Archive includes a field for measurement uncertainty to accompany each data value. Each participant who submits data, also submits an estimate of uncertainty with his or her data. The uncertainty field may represent precision or a combination of accuracy and precision, depending on how the uncertainty was determined. ENSR reviews the basis for measurement uncertainty in conjunction with the measurement specific managers, compares this with QA audit or intercomparison results when possible, and compiles an assessment of measurement accuracy and precision for each measurement.

Most uncertainties determined through internal QC checks (i.e., checks applied by the participant while collecting data), such as replicate sampling, frequent calibration checks, or x-ray counting statistics, generate measures of precision. Manufacturer's specifications, e.g., for meteorological instrumentation, often report accuracy and precision. However, these should be considered precisions by the data base user. Accuracy is usually affected by errors involving improper calibration or operation that result in inaccurate data (e.g., a wind direction sensor not accurately aligned with true north).

External QA checks such as system and performance audits provide accuracy checks for the components of a measurement. For example, flow rate audits and chemistry laboratory audits can confirm the accuracy of sample volume and filter concentration determinations for the SCAQS sampler. Assumptions regarding transport of particles and gases through the sampler to the filter, filter collection efficiency, filter artifacts, sample handling, etc. remain untested. System audits review assumptions and procedures, and attempt to verify that well characterized, accurate procedures are being used.

External QA checks such as intercomparisons among different methods provide accuracy checks for an overall measurement. For example, the integrating plate method for measuring the light absorption of an aerosol collected on a filter, is known to overestimate the aerosol's atmospheric absorption coefficient. A correction factor is applied, but the factor is not known accurately. Comparison of the integrating plate method with measurements of elemental carbon, or with absorption coefficient determined through teleradiometry, provides a check on accuracy of the final measurement without checking component measurements or assumptions.

Additional verification of data accuracy is provided by the data validation process. This process will be described in detail in ENSR's final report to the ARB on SCAQS Data Management. In brief, the validation process screens measurements for unusual behavior such as outliers or sharp temporal spikes, checks for consistency among different methods and measurements of similar species, and checks for physical consistency in the relationships among measurements of different species. The validation is performed in three phases: by the participants, before data are submitted to the data manager; by the data management team in conjunction with the participants, after data are received by the data manager; and finally, by users of the data, after data have been released to the scientific community. The data validation process produces two results: first, problems are identified, documented, and corrected where feasible, thus improving the quality of data in the archive; second, the results of data validation tests are incorporated as flags and comments in the Archive, thus enhancing the usability of the Archive.

The early stages of data validation, including validation performed by the participants and screening of univariate data displays, are being performed now. Formal collections of validation tests are being compiled for each measurement, and will be applied during the second and third quarters of 1989. As researchers use data during the coming years, it is inevitable that new problems will arise, and the SCAQS Data Archive will need further updates. The mechanism is in place now to document the identification and resolution of future data problems, and any resulting modifications to the archive. Thus, QA will continue to be an integral part of the SCAQS program for years to come.

The issues affecting accuracy and precision are as diverse as the SCAQS measurements. While the results of external QA audits are quantitative, they are generally too few to summarize statistically, and are not available for all measurements. Further, accuracy data and accuracy questions usually apply to an entire measurement set, whereas it is often appropriate to calculate precisions for individual data values using propagation of errors. Thus, uncertainties in the SCAQS Data Archive depend primarily on internal QC data and primarily represent precision.

Estimates of lower detection limits, precisions, and accuracies for each SCAQS measurement have been compiled in Table 7-1. This table includes a discussion of those issues known to affect accuracy that are difficult to quantify. The discussions also compare audit and intercomparison results with accuracies and precisions reported by the participants.

TABLE 7-1

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Nitrous Acid

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
HONO	AIHL	Appel	Annular denuders counted with Na2CO3-glycerine and analysis of NO2 by IC	LBCC	Summer Fall	0.6 ppb	+/- 10%			Positive bias due to: 1. Partial retention of NO2 on collection media. 2. Formation of HONO on sampler inlet and other surfaces. 3. Hydrolysis of PAN.
HONO	UCR	Winer	DOAS	CLARE LBCC LBCC	Summer Fall	0.6 ppb	+/- 15%			

Measurement Catagory: Peroxides

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
H2O2	CE	Brookhaven	Impinger using peroxide catalyzed p-hydroxyphenylacetic acid fluorescense tech. NO to remove O3, HCHO, SO2	CLARE,DOLA LBCC, RUB	Summer	0.5 ppb	0-1 +/-40 1-2 +/-7% <2 +/-4%			1. Positive bias from O3 neg. interf. reaction with SO2->HMSA 2. Line loss of 7% to 40% 3. CE's values near one order magnitude higher than Unisearch TDLAS data
H2O2	Unisrch	Mckay	TDLAS	CLARE LBBC	Summer Fall	0.5 ppbv	+/- 10%			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Nitric Acid

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
HNO3	AIHL	Appel	Annular Denuder coated with Na2CO3-glycerol	LBCC LBCC	Summer Fall	0.2 ppb	+/- 10%			
HNO3	ARB	Horrocks	Denuder Difference	CLARE	Summer	0.1 ppb	per data			
HNO3	CE/AV		SCAQS Sampler Denuder difference	7B & 2A 5A & LBCC	Summer Fall	.3 ppb	+/- 11%			Precision from side-by-side test of ten samplers by AV
HNO3	EPA	Knapp	Transition Flow Reactor	CLARE, RUB LBCC LBCC, DOLA	Summer Fall	0.9 ppb	+/- 10%			
HNO3 aloft	STI/UW	Anderson/ Hegg	Aircraft: filter chemistry	------	Both	6 ug/m^3	per data			
HNO3	Unisrch	McKay	TDLAS	CLARE	Summer	0.1 ppbv	+/- 10%	+/- 20%		

Measurement Catagory: Ammonia/Ammonium

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
NH3	AIHL	Appel	Annular denuder citric acid-glycerine	LBCC	Summer Fall	.15 ppb	+/- 5%			Sampler designed to keep line loss to a minimum.
NH4 all cuts	AIHL	John	Berner Impactor for inorganic ion size distrubutions	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	.07ug/m^3	+/- 3%	8 - 10%		
NH3 Gaseous NH4 PM10 NH4 PM2.5 NH4	CE/AV		SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	1 ug/m^3	+/- 42%		audit: 5-10% comparison: 3-8%	Precision based on side by side test.
NH3 Gaseous NH4 PM10 NH4 PM2.5 NH4	STI/UW	Anderson/ Hegg	Aircraft: filter chemistry	------	Both	NH_4: 0.6 ug/m^3 NH_3: 2.5 ug/m^3	per data			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Carbonyls

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Formaldehyde Acetaldehyde Acetone Acrolein Propanol Methylethyl-ketones Butyaldehyde Pentenal Benzaldehyde	ENSR	Fung	DNPH cartriges and sequential sampler and HPLC.	7B & 2A 5B & LBCC	Summer Fall	0.1 ppb	+/- 10%			
Formaldehyde Acetaldehyde + 20 other carbonyls	EPA	Lonneman	DNPH Sep-pak & HPLC	DOLA LBCC CLARE	Summer	?	?			
Formaldehyde	STI/UW/ ENSR	Wright	Aircraft: for carbonyls	------	Both	1.4 ppb	1.12 ppb			
Acetaldehyde						0.9	0.89 ppb			
Acetone						1.2	1.32 ppb			
Acrolein						1.0	0.30 ppb			
Propanal						0.3				
MEK						1.2	0.93 ppb			
Butanal						0.6	0.32 ppb			
Pentanal						1.2	0.84 ppb			
Hexanone						0.6	0.71 ppb			
Benzaldehyde						0.9	0.34 ppb			
Formaldehyde	UCR	Winer	Differential Optical absorbtion spectrometry	LBCC CLARE LBCC	Summer Fall	3.0 ppbv	+/- 30%			
Formaldehyde	Unisrch	Mckay	Tunable diode laser absorption spectrometry (TAMS-150)	CLARE LBCC	Summer Fall	0.1 ppbv	+/-10%			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: HC Speciation

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
C4 - C12 hydrocarbons	EPA	Knapp & Stockburger	SS cannisters/GC propane standard	7B & 2A 5B & LBCC	Summer Fall	MQL: .15 ppb MDL: .05 ppb	+/- 15%			MQL: Minimum quantifiable limit Interference: any compound that elutes with same retention time responds to FID.
C2 - C12	EPA	Lonneman	Calib. by propane NBS	CLARE,DOLA LBCC	Summer	MQL: .12 ppb MDL: .04 ppb	+/- 12%			
C2 - C9 hydrocarbons	OGC	Rassmussen	SS cannisters/GC. Benzene propane & methane primary NBS SRM C2-C10 calibration standard are traceable to the NBS standard through neo-hexane	7B & 2A 5B & LBCC	Summer Fall	.04 ppb	C2-C4: 2% C4-C10:5%			
Hydrocarbons	STI/UW/ EPA	Knapp	Aircraft: for hydrocarbons	------	Both	?	?			

Measurement Catagory: PAN

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
PAN	DGA	Grosjean	PAN by GC, electron capture	7B & 2A ANA, DOLA HAW, LBCC	Summer Fall	1 ppb	+/- 15%			
PAN aloft	DGA/STI/ UW	Grosjean	Aircraft: PAN	------	Both	per data	per data			
PAN	EPA	Lonneman/ Ellenson	PAN by GC, electron capture	CLARE	Summer	?	?			
PAN	UD	Stedman	PAN by GC luminal detector	CLARE	Summer	?	+/- 10%			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Oxides of Nitrogen

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
NO NO2 Artifact NO2	AIHL	Appel	Modified TECO 14B/E with Na2CO3-glycerol denuder	LBCC	Fall	?	?			
NO NO2 NOx	AQMD	Bope		ANA, AZUSA DOLA, HAW ANA, DOLA, HAW, RUB	Summer Fall	.001 ppm	.001 ppm	2-3%	audit: 2-6% for NO2	
NO NO2	ARB	Kowalski	Monitor Labs 8440	LBCC	Both	.004 ppm	.001 ppm		audit: 5-10% for NO2	
NO2	ARB	Jung	Dasibi 2008	CLARE LBCC	Summer Fall	?	?			
NO NO2 NOx	AV	Chan	Monitor Labs 8440	SNI	Summer	.004 ppm	.001 ppm			
NOx	EPA	Lonneman/ Ellenson	Monitor Labs 8440 with prefilter	CLARE	Summer	.004 ppm	.001 ppm			
NO NO2 NOx	GM	Wolff	Monitor Labs	CLARE LBCC	Summer Fall	.004 ppm	+/- 6%		audit: 5-10% for NO2	
NO NOx	SCE/AV	Games	Monitor Labs 8440E	Alamitos	Both	.004 ppm	.001 ppm			
NO NO2 NOx	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry	------	Both	.004 ppm	1 ppb		audit: 10-12% for NO2	
NO2	UCR	Winer	DOAS	CLARE,LBCC LBCC	Summer Fall	?	?			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Carbon Monxide

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
CO	AQMD	Bope		ANA, AZUSA HAW, DOLA ANA, DOLA, HAW, RUB	Summer Fall	.001 ppm	.001 ppm	2-3%	audit: 5%	
CO	ARB	Kowalski	Dasibi 3003	LBCC	Both	.1 ppm	.1 ppm		audit: 2-6%	
CO	AV	Chan	Dasibi 3003	SNI	Summer	.1 ppm	.1 ppm			
CO	GM	Wolff	Dasibi	CLARE LBCC	Summer Fall	?	+/- 8.5%		audit: 5-10%	
CO	SEC/AV	Games	Dasibi 3003	Alamitos	Both	.1 ppm	.1 ppm			
CO aloft	STI	Anderson	Aircraft	------	Both	?	?		audit: 3%	

Measurement Catagory: Ozone

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
O3	AIHL	Appel	Dasibi 1003AH	LBCC	Both	.004 ppm	.001 ppm			
O3	AQMD	Bope		ANA, AZUSA HAW, DOLA ANA, DOLA, HAW, RUB	Summer Fall	.001 ppm	.001 ppm	2-3%	audit: 5-10%	
O3	ARB	Kowalski	Dasibi 1003	LBCC	Both	.004 ppm	.001 ppm		audit: 5%	
O3 aloft	ARB	Bennett	Aircraft: Dasibi 1003	------	Summer	.004 ppm	.005 ppm		audit: 5%	
O3	AV	Chan	Dasibi 1003-AH	SNI	Summer	.004 ppm	.001 ppm			
O3	GM	Wolff	Dasibi	CLARE LBCC	Summer Fall	.004 ppm	+/- 6.5%		audit: 5%	
O3	GM	Wolff	Monitor Labs	CLARE LBCC	Summer Fall	?	+/- 6.5%		audit: 5%	
O3	SEC/AV	Games	Dasibi 1003-AH	Alamitos	Both	.004 ppm	.001 ppm			
O3 aloft	STI/UW	Anderson/ Hegg	Aircraft	------	Both	?	7 ppb		audit: 5-12%	

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Wind Speed

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
WS	AQMD	Bope		ANA, AZUSA HAW, DOLA	Summer	0.5 mph	1.0 mph			
				ANA, DOLA, HAW, RUB	Fall					
WS	ARB	Kowalski		LBCC	Both	?	.3 m/s			
WS	AV	Chan	MRI 1022	SNI	Summer	.223 m/s	.067 m/s			
WS V_WS	GM	Wolff	Climatronix	CLARE LBCC	Summer Fall	?	?			
WS	SEC/AV	Games	MRI 1022	Alamitos	Both	.223 m/s	.067 m/s			

Measurement Catagory: Wind Direction

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
WD	AQMD	Bope		ANA, AZUSA HAW, DOLA	Summer	WS=.5 mph	2.5 deg.			
				ANA, DOLA, HAW, RUB	Fall					
WD	ARB	Kowalski		LBCC	Both	?	?			
WD	AV	Chan	MRI 1022	SNI	Summer	WS=.3 m/s	2.5 deg.			
WD V_WD	GM	Wolff	Climatronx	CLARE LBCC	Summer Fall	?	10 deg			
WD	SEC/AV	Games	MRI 1022	Alamitos	Both	WS=.3 m/s	2.5 deg.			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Temperature

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
TEMP	AQMD	Bope		ANA, AZUSA HAW, DOLA ANA, DOLA, HAW, RUB	Summer Fall	N/A	1 degF	2%		
TEMP	ARB	Kowalski		LBCC	Both	N/A	?			
TEMP	AV	Chan	MRI 1022	SNI	Summer	N/A	.10 degC			
TEMP TEMP5 TEMP10 T1 - T10	GM	Wolff	Climatronix	CLARE LBCC	Summer Fall	N/A	.15 degC			
TEMP	SEC/AV	Games	MRI 1022	Alamitos	Both	N/A	.10 degC			
TEMP aloft	STI/UW	Anderson/ Hegg	Aircraft	------	Both	N/A	.1 degC			

Measurement Catagory: Dew Point

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
DWPT	AQMD	Bope		ANA, AZUSA HAW, DOLA ANA, DOLA, HAW, RUB	Summer Fall	N/A	1.0 degF	2%		
DWPT	ARB	Kowalski		LBCC	Both	N/A	?			
DWPT	AV	Chan	MRI 1022	SNI	Summer	N/A	0.1 degC			
DWPT	GM	Wolff	Climatronix	CLARE LBCC	Summer Fall	N/A	0.15 degC			
DWPT	SEC/AV	Games	MRI 1022	Alamitos	Both	N/A	0.1 degC			
DWPT aloft	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry	------	Both	N/A	1.0 degC			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Carbon

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
PM10 EC PM2.5 EC PM10 OC PM2.5 OC	ENSR/AV	Taketomo	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	OC: 3.6 ug/m^3 EC: 0.2 ug/m^3	per data			
EC all cuts OC all cuts	UM	McMurry	MOUDI for sizes: < .032um; .034-.072um; .072-.17um; .17-.28um; .28-.56um; .56-1um; 1-1.8um; 1.8-3.2	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	OC: 1.0 EC: 0.5 ug/m^3 per stage	1ug + 5% per stage			
in-situ EC in-situ OC in-situ TC	OGC	Huntzicker	In-situ elemental, organic and total carbon	CLARE LBCC	Summer Fall	0.3 ug/m^3	+/- 3.1%			
PM10 EC PM2.5 EC PM10 OC PM2.5 OC	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry carbon aloft	------	Both	EC: 3.0 ug/m^3 TC: 5.0 ug/m^3	per data			
PM10 EC PM2.5 EC PM10 RC PM2.5 RC	UCLA-2	Main	Dichotomous sampler for elemental and organic carbon	CLARE	Summer	OC: 7.0 ug/m^3 EC: 0.4 ug/m^3	+/- 12%			

Measurement Catagory: Bsp

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Bsp	AQMD	Bope	MRI 1560	ANA, AZUSA HAW, DOLA ANA, DOLA, HAW, RUB	Summer Fall	3E-5/m	10%			LDL from manual - zero drift indicated on calibration sheets.
Bsp	AV	Chan	MRI 1560	CLARE,LBCC RUB, SNI LBCC	Summer Fall	3E-5/m	10%			
Bsp	GM	Wolff	Modified MRI 1550	CLARE LBCC	Summer Fall	3E-6/m	7%			
Bsp aloft	STI/UW	Anderson/ Hegg	Aircraft: MRI 1569	------	Both	3E-6/m	+/- 10^{-6}/m			
Bsp	UI	Rood	Nephelometer	CLARE, RUB	Summer	3E-6/m	4%	5%		

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Babs

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Babs	Ford	Adams	Spectrophone	CLARE	Summer	3E-6/m	5E-6/m			
Babs	LBL	Hansen	Aethelometer 2 size cuts: < .3um and < 1um	CLARE	Summer	6E-6/m	Max of 20% and 5E-6/m	5%		Participants should call Dr. Hansen about precision.
Babs	RR/AV	Weiss	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	8E-6/m	per data			Filter absorption over estimates aerosol Babs by ~20%
Babs aloft	RR/STI/ UW	Weiss/ Anderson/ Hegg	Aircraft: Filter chemistry	------	Both	10^{-6}/m	per data			
Babs	UCD	Matsumura	IMPROVE teflon filter	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	per data	per data			
Babs	U.Vienna	Hitzen- berger	Nuclepore filter	CLARE LBCC	Summer Fall	?	5%			

Measurement Catagory: Bext

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Bext	STI	Richards	Teleradiometer	CLARE	Summer	20/Mm	per data			
Bext	U.Vienna	Hitzen- berger	Telephotometer for 10 wavelengths	CLARE LBCC	Summer Fall	?	per data			

Measurement Catagory: Path Radiance

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Path Radiance	STI	Richards	Teleradiometer	CLARE	Summer	4.0 $W/m^2/st/um$	per data			

Measurement Catagory: Ultraviolet Radiation

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
UV	ARB	Kowalski	Epply UV photometer	MW	Summer	N/A	7 ly/min			
UV	AV	Chan	Epply UV photometer	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	N/A	7 ly/min			
UV	GM	Wolff	Epply	CLARE LBCC	Summer Fall	N/A	7 ly/min			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Solar Radiation

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
SOLARAD	GM	Wolff	Epply	CLARE LBCC	Summer Fall	N/A	7 ly/min			

Measurement Catagory: Relative Humidity

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
RH	GM	Wolff	Climatronix	CLARE LBCC	Summer Fall	?	5%			

Measurement Catagory: Sulfur Dioxide

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
SO2	ARB	Kowalski	TECO 43	LBCC	Both	?	?		audit: 28%	
SO2	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	.1 ug/m3	per data			
SO2	SEC/AV	Games	Meloy 285E	Alamitos	Both	1% full scale	1% full scale			
SO2 aloft	STI	Anderson	Aircraft: Filter chemistry	------	Both	0.6 ug/m^3	1.0 ppb		audit: 3%	

Measurement Catagory: Sulfate

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
SO4 all size fractions	AIHL	John	Berner Impactor for inorganic ion size distrubutions	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	.06 ug/m^3	+/- 3%	5%		
PM2.5 SO4	ARB	Horrocks	Denuder Difference	CLARE	Summer	.07 ug/m^3	per data			
PM10 SO4	AV/AQMD	Eden	Anderson SSI HiVol	7B & 2A 5B & LBCC	Summer Fall	0.1 ug/m^3	.04 ug/m^3			
PM10 SO4 PM2.5 SO4	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	.04 ug/m^3	per data		audit: 5-10% comp.: 5-10%	
TOTAL SO4	EPA	Knapp	TFRs for inorganics	CLARE LBCC	Summer Fall	.07 ug/m^3	+/- 7%			
PM10 SO4 PM2.5 SO4	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry SO4 aloft	------	Both	0.6 ug/m^3	per data			
PM10 SO4 PM2.5 SO4	UCLA-2	Main	Dichotomous Sampler Teflon filter with Nylasorb backup filter	CLARE	Summer	.1 ug/ filter	+/- 10%			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Nitrate

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
NO3 all size fractions	AIHL	John	Berner Impactor for inorganic ion size distrubutions	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	.06 ug/m^3	+/- 3%	5%		
PM2.5 NO3	ARB	Horrocks	Denuder Difference	CLARE	Summer	0.5 ug/m^3	+/- 10%			
PM10 NO3	AV/AQMD	Eden	Anderson SSI HiVol	7B & 2A 5B & LBCC	Summer Fall	0.1 ug/m^3	.05 ug/m3			
PM10 NO3 PM2.5 NO3 TOTAL NO3	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	2.0 ug/m^3	per data		audit: 3-8% comparison: 3-8%	
TOTAL NO3	EPA	Knapp	TFRs for inorganics	CLARE LBCC	Summer Fall	5.0 ug/m^3	+/- 10%			
PM10 NO3 PM2.5 NO3 TOTAL NO3 GASEOUS NO3	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry NO3 aloft	------	Both	0.6 ug/m^3	per data			
PM10 NO3 PM2.5 NO3	UCLA-2	Main	Dichotomous Sampler Teflon filter with Nylasorb backup filter	CLARE	Summer	0.3 ug/m^3	10%			

Measurement Catagory: Chloride

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
PM10 Cl	AV/AQMD	Eden	Anderson SSI HiVol	7B & 2A 5B & LBCC	Summer Fall	0.1 ug/m^3	.05 ug/m3			
PM10 Cl PM2.5 Cl	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	0.5 ug/m^3	per data			
PM10 Cl PM2.5 Cl	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry Cl aloft	------	Both	0.6 ug/m^3	per data			

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: Mass

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
PM10 Mass	AV/AQMD	Eden	Anderson SSI HiVol	7B & 2A 5B & LBCC	Summer Fall	5 ug/m^3	.05 ug/m3			
PM10 Mass PM2.5 Mass	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	12 ug/m^3	per data			
Mass	IIT	Noll	Rotary impactor, four size cuts	CLARE	Summer	?	+/- 10%			
PM10 Mass PM2.5 Mass	STI/UW	Anderson/ Hegg	Aircraft: Filter chemistry Mass aloft	------	Both	5 ug/m^3	per data			
PM10 Mass PM2.5 Mass	UCLA-2	Main	Dichotomous Sampler Teflon filter with Nylasorb backup filter	CLARE	Summer	8 ug/m^3	10%			

Measurement Catagory: Sodium

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
Na all cuts	AIHL	John	Berner Impactor for inorganic ion size distrubutions	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	.06ug/m3	3%	8-10%		
PM10 Na	CE/AV	Countess	SCAQS Sampler	7B & 2A 5B & LBCC	Summer Fall	1 ug/m^3	per data			

Measurement Catagory: Particle Size Distributions

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
OPC PRB EAA	AV	Moon	Climet 208, PMS LASX Probe TSI 3030 EAA	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	N/A	+/- 5%			OPC: .5-7um optical size number distribution PRB: .1-3um optical size number distribution EAA: .006-.56um electrical mobility number distribution
DMA	U.Vienna	Reischl	Univ. Vienna Diff. Mobility Analyzer	CLARE,LBCC DOLA, LBCC	Summer Fall	N/A	?			DMA: .003-.15um electrical mobility number distribution

TABLE 7-1 CONTINUED

UNCERTAINTY FOR SCAQS MEASUREMENTS

Measurement Catagory: XRF/DRUM/IMPROVE

Parameter(s)	Group	PI	Method	Location	Season	LDL	Precision	Accuracy	Audit/Comparison	Comments
PM10 XRF PM2.5 XRF	EPA/AV	Knapp	SCAQS Sampler XRF	7B & 2A 5B & LBCC	Summer Fall	1 ug/cm2	per data	+/- 15%	See Sect. 6.3.1	See Section 6.3.1
PM10, PM2.5 Ag Al As Ba Br Ca Cd Cl Cr Cu Fe Ga Hg In K La Mn Mo Na Ni P Pb Pd Rb S Sb Se Si Sn Sr Ti V Y Zn Zr Mass	SCE/AV	Games	XRF by NEA	Alamitos	Both	.01-.07 ug/m3	per data			
PM2.5 Al As Br Ca Cr Cu Fe K Ma Mn Ni Pb S Se Si Ti V Zn	UCD	Matsumura	IMPROVE teflon filters for PM2.5 by PIXE	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	per data	per data			
Ca Cl Fe K S Zn	UCD	Matsumura	DRUM by PIXE for size cuts < .069um; .069um-.24um; .24um-.34um; .34um-.56um; .56um-1.15um; 1.15-2.12um 2.12um-4.26um; 4.26-8.54um 8.54um-15um	CLARE,LBCC RUB DOLA, LBCC	Summer Fall	per data	per data			
PM10, PM2.5 Ag Al As Ba Br Ca Cd Cl Cr Cu Fe Ga Hg In K La Mn Mo Ni P Pb Pd S Se Si Sn Sr Ti V Y Zn Zr	UCLA-2	Main	XRF dichots	CLARE	Summer	.4 ug/cm	per data			

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9. GLOSSARY

ARB	California Air Resources Board
AV	AeroVironment
b_{abs}	particle light absorption coefficient
CAS	Chemical Abstract Service
C-E	Combustion Engineering: C-E Environmental, Inc Camarillo, California
CRC	Coordinating Research Council
CSI	Columbia Scientific, Inc.
CSMCS	Carbonaceous Species Methods Comparison Study
DGA	DGA, Inc.
DNPH	dinitrophenolhydrazine
DOAS	differential optical absorption spectroscopy
DOE	Department of Energy
DRI	Desert Research Institute
DRUM	Davis rotating-drum universal-size-cut monitoring-sampler
EAA	electrical aerosol analyzer
EMSI	Environmental Monitoring and Services, Inc.
ENSR	ENSR Consulting and Engineering, Camarillo, California
EPA AREAL	Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, North Carolina
EPA/NSI	Northrop Services Inc, under contract to EPA AREAL
EPA(L)	Gas Phase Photochemistry Branch
EPA(S)	Heterogenous Chemistry and Aerosol Research Branch
FTIR	Fourier transform infrared
GC	gas chromatography

GC-MS	gas chromatography with mass spectrometry
GM	General Motors Research Laboratories, Warren, Michigan
HC	hydrocarbon
INAA	Instrumental Neutron Activation Analysis
IPM	integrating plate method
LIDAR	light detecting and ranging
MOUDI	micro orifice uniform deposit impactor
MSM	Measurement Specific Manager. *SCAQS measurements have been broken into a number of measurement areas and a MSM has been assigned to oversee the consistency and quality of data within each measurement area.*
NASN	National Air Surveillance Network
NEA	NEA, Inc., Beaverton, Oregon
NSI	NSI Technology Services Corporation
NSMCS	Nitrogen Species Methods Comparison Study
OGC	Oregon Graduate Center
OPC	optical particle counter
PAN	peroxyacetyl nitrate
PIXE	particle-induced x-ray emission
QA	Quality Assurance. *Reviews and audits by external personnel to verify that measurement methods and QC procedures are adequate to achieve desired results, to verify that these procedures are being followed, and to test whether the desired representativeness, accuracy and precision is achieved in practice.*
QC	Quality Control. *Documentation and procedures to control and verify the representativeness, accuracy and precision of measurement data. These procedures are applied by the group performing the measurements.*
SoCAB	South Coast Air Basin
SCAQMD	South Coast Air Quality Management District
SCAQS	Southern California Air Quality Study

SSI	size-selective inlet
SOP	standard operating procedure
STI	Sonoma Technology, Inc.
TDLAS	tunable diode laser absorption spectrometer
THC	total hydrocarbons
TSD	Technical Services Division
UCD	University of California, Davis
UW	University of Washington
XRF	x-ray fluorescence